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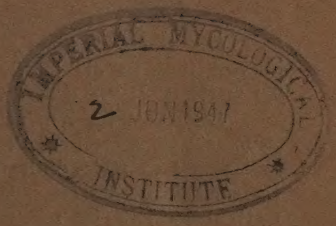

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MATHEMATICS

GENERALIZATION OF A BAIRE'S THEOREM

By B. GAGAIEV

(Communicated by S. L. Soboleff, Member of the Academy, 27.VII. 1942)

R. Baire has shown (1) that if the values of a function of the class $\alpha \geqslant 2$ are altered arbitrarily on an enumerable set, then the class of the function does not increase. This theorem admits generalizations in two directions, namely, it is possible: 1) to find such non-enumerable point sets that at any alteration of a function of the class $\alpha \geqslant 2$ on these sets the class does not increase, or 2) to find such non-enumerable point sets that at any alteration of a function of the class $\geqslant \beta > 2$ on these sets the class does not increase. On every non-enumerable point set there exist, however, 2^C functions, provided that the cardinal number of the continuance is C, and in the same time the cardinal number of all functions of the Baire classification is C. So we must confine ourselves to such alterations of the function that the altered function remains within the Baire classification.

In this paper we give a generalization of the theorem while taking the first direction. We establish the necessary and sufficient conditions that should be imposed on the set in order that a function of the class $\geqslant \alpha$ may be altered arbitrarily on it without increasing the class, provided that the altered function remains within the Baire classification.

Theorem 1. *The class greater than or equal to $\alpha+1$ of the function $f(x)$ defined on the set M does not increase at any such alteration of $f(x)$ on a set N that does not take the function out of the Baire classification if and only if the intersection between N and every B-set with respect to M is F_α with respect to M*.*

Let $f(x)$ be carried into the function $\varphi(x)$ belonging to the Baire classification by an alteration on a set N satisfying the condition of the theorem. Consider the function $\omega(x) = f(x) - \varphi(x)$. This function vanishes on the set $M - N$. It belongs to the class not higher than $\alpha+1$ if and only if the sets

$$E[\omega(x) \geqslant a] \quad \text{and} \quad E[\omega(x) \leqslant a]$$

are $F_{\alpha+1}$ for any a. If $a > 0$, then the former set, being a subset of N that is B-measurable with respect to M, is F_α with respect to M. Analogously, if $a < 0$, then the latter set is F_α with respect to M. If $a = 0$, then

$$E[\omega(x) \geqslant a] = M - E[\omega(x) < a].$$

Since $E[\omega(x) < a]$ for $a = 0$ is a subset of N that is B-measurable with respect to M, it is F_α with respect to M. Consequently, for $a = 0$ the set $E[\omega(x) \geqslant a]$ is G_α with respect to M, and hence is $F_{\alpha+1}$ with respect to M. Quite analogously $E[\omega(x) \leqslant a]$ is $F_{\alpha+1}$ with respect to M for $a = 0$. Thus,

* For the set M there exists a non-enumerable set N satisfying the condition of the theorem if and only if M is not an A-set.

$\omega(x)$ is of the class not higher than $\alpha+1$ and hence the class of $\varphi(x)$ is not higher than that of $f(x)$, provided that the latter is $\leqslant \alpha+1$. The sufficiency of the condition is thus proved. To prove the necessity suppose that there exists a subset Q of the set N that is F_β with respect to M and $\beta > \alpha+1$. Then the characteristic function $\omega(x)$ of the set Q equal to 1 on Q and to 0 elsewhere will be of the class $\beta+1 > \alpha+1$ with respect to M, and hence the function $\varphi(x) = f(x)+\omega(x)$ will be of the class $\beta+1$ that exceeds $\alpha+1$, the class of $f(x)$.

As an example of the set satisfying the condition of our theorem consider the set constructed by Sierpinski [2], assuming the hypothesis of the continuance be correct; the intersection of this set with any null set is non-enumerable. In fact, denote this set by S. The intersection between S and any set Q that is B-measurable with respect to M is F_1 with respect to M. It is so, if Q is a null set, because the intersection of Q and S, being enumerable, is then F_1. If Q is of positive measure μ, then it can be represented as Q_1+Q_2, where Q is F_1 with respect to M of measure μ, and Q_2 is of measure zero and consequently is also F_1. Altering the function $f(x)$ of the class $\geqslant 2$ on S, we cannot transform $f(x)$ into a function of a higher class, provided that we do not take it out of the Baire classification. But Sierpinski has shown that every non-enumerable subset of S is not L-measurable. Consequently, if M itself is measurable, then the alteration of the function $f(x)$ on every non-enumerable subset of S takes the function out of the Baire classification. To avoid this we must assume M to be not L-measurable itself. In this case the intersection between S and a subset of M B-measurable with respect to M can be non-enumerable, and we thus obtain the following generalization of Baire's theorem in the first direction.

An arbitrary alteration on the set S of a function defined on the set M and belonging to the class $\geqslant 2$ with respect to M does not carry it into a function of a higher class, provided that the altered function remains within the Baire classification.

The set S possesses also the interesting property that any function defined on it is, as has been shown by Szpilrajn [3], *of the class $\leqslant 1$ with respect to S, if it only belongs to the Baire classification.*

The existence of sets satisfying the condition of the theorem for $\alpha > 1$ remains to be proved.

Corollary 1. *If the set N satisfies the condition of the theorem and $f(x)$ is a function of the class $\beta \leqslant \alpha$ with respect to M, then the class of the function cannot increase more than to $\alpha+1$ at any alteration of $f(x)$ on N, provided that the function is not taken out of the Baire classification.*

This corollary follows immediately from the proof of the theorem.

Corollary 2. *If N is the set satisfying the condition of the theorem and $f(x)$ is the function of the class $\geqslant \alpha+2$ with respect to M, then the class remains invariant at any alteration of the function on N, provided that the function is not taken out of the Baire classification.*

Let the altered function $\varphi(x)$ belong to one of the Baire classes. It follows from our theorem that the class of $\varphi(x)$ is not higher than that of the initial function $f(x)$. If it were lower, then the inverse alteration would transform $\varphi(x)$ into $f(x)$ and the class of the latter would be higher than that of $\varphi(x)$; namely, $> \alpha+1$, that contradicts Corollary 1.

Consider now such alterations of function on N that are subject to some restrictions.

Theorem 2. *If the function $f(x)$ defined on the set M is of the class γ with respect to M and $\varphi(x)$ is the function obtained from $f(x)$ by such alterations of its values on the set $\sum N_k$, where the sets N_k are mutually exclusive and every N_k is F_α, that on every N_k $\omega(x) = f(x)-\varphi(x)$ is of the class $\leqslant \beta$ with respect to M, then $\varphi(x)$ is either of the class $\leqslant \gamma$, if $\gamma-2$ is not less than the maximum of α and β, or of the class γ, if $\gamma-3$ is not less than the maximum of α and β.*

To determine the class of the function $\varphi(x)$ it suffices to determine the type of sets

$$E[\omega(x) \geqslant a] \quad \text{and} \quad E[\omega(x) \leqslant a]$$

for an arbitrary a.

If $a > 0$, then

$$E[\omega(x) \geqslant a] = E[\omega(x) \geqslant a] \sum N_k.$$

But $E[\omega(x) \geqslant a] N_k = E[\omega(x) \geqslant a] M N_k$, and, since $E[\omega(x) \geqslant a] M$ is F_β with respect to M and N_k is F_α, $E[\omega(x) \geqslant a] N_k$ is F_δ, where δ is the maximum of β and γ. The set $F[\omega(x) \geqslant a]$ is thus $F_{\delta+1}$. Analogously, one can see that for $a < 0$ the set $E[\omega(x) \leqslant a]$ is $F_{\delta+1}$. If $a = 0$, then

$$E[\omega(x) \geqslant a] = M - E[\omega(x) < a].$$

But $E[\omega(x) < a] = E[\omega(x) < a] \sum N_k$ and $E[\omega(x) < a] N_k = E[\omega(x) < a] M N_k$. As $E[\omega(x) < a] M$ is G_β and N_k is F_α, i. e. $G_{\alpha+1}$, $E[\omega(x) < a] N_k$ is $G_{\delta+1}$ and $E[\omega(x) < a]$ is $G_{\delta+2}$. Consequently, $E[\omega(x) \geqslant a]$ is $F_{\delta+2}$. In the same way one can prove that the set $E[\omega(x) \leqslant a]$ is $F_{\delta+2}$ for $a = 0$. We see that $\omega(x)$ is of the class $\leqslant \delta+2$ with respect to M, i. e. the class of $\varphi(x)$ cannot exceed $\delta+2$. Consequently, if $f(x)$ is of the class $\alpha \geqslant \delta+2$, then $\varphi(x)$ is of the class $\leqslant \alpha$; if $\alpha \geqslant \delta+3$, then $\varphi(x)$ is of the class α, because otherwise the class of $\varphi(x)$ would increase more than to $\delta+2$ at the alteration of $\varphi(x)$ on the set $\sum N_k$, which is impossible.

Putting $\alpha = \beta = 0$, we obtain the following generalization of Baire's theorem:

If the function $f(x)$ defined on M is of the class γ with respect to M and $\varphi(x)$ is obtained from $f(x)$ by such an alteration of $f(x)$ on $\sum N_k$, where N_k are mutually exclusive closed sets, that $\omega(x) = f(x) - \varphi(x)$ is continuous on every N_k with respect to M, then $\varphi(x)$ is of the class $\leqslant \gamma$, when $\gamma \geqslant 2$, and of the class γ, when $\gamma = 0$.

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MATHEMATICS

ON SPECIAL EXTENSIONS OF TOPOLOGICAL SPACES

By N. A. SHANIN

(Communicated by A. N. Kolmogoroff, Member of the Academy, I.VI.1942)

§ 1. Remarks on Terminology and Notation

Any set ot sets will be called family. The family of all finite intersections of elements of a family $\mathfrak{A}$ will be denoted by $\Delta\mathfrak{A}$; the family of all finite sums of elements of $\mathfrak{A}$—by $\nabla\mathfrak{A}$. The empty set will be denoted by Λ.

If E is a T-space (i. e. if the family of closed sets in E satisfies the conditions: E and Λ are closed sets, the sum of a finite set and the intersection of an arbitrary set of closed sets are closed sets), then $\mathfrak{F}_E$ will denote the family of all closed sets in E, and $\mathfrak{G}_E$, the family of all open sets in E. The closure of $A \subset E$ in the T-space E will be denoted by $\overline{A}^E$; the interior of A in E, by $\underline{A}_E$. A family $\mathfrak{A}$ will be called a closed basis of the T-space E, if $\mathfrak{A} \subset \mathfrak{F}_E$ and every set $F \in \mathfrak{F}_E$ can be represented as the intersection of a non-empty set of elements of $\mathfrak{A}$ (it is obvious that $E \in \mathfrak{A}$). The closed basis $\mathfrak{A}$ of the T-space E is said to be reduced if $\Lambda \in \mathfrak{A}$ and the sum of any finite set of elements of $\mathfrak{A}$ is an element of $\mathfrak{A}$ (i. e. if $\nabla\mathfrak{A} = \mathfrak{A}$).

Definition 1. Let S be a T-space, $R \subset S$ and $\mathfrak{B} \subset \mathfrak{F}_R$. We say that the family $\mathfrak{B}$ is a closed framework of the T-space S in the subspace R, if the totality of closures in S of all the elements of $\mathfrak{B}$ is a closed basis of S.

If $R \subset S$ and $\mathfrak{F}_R$ is a closed framework of S in R, then obviously $\overline{R}^S = S$. The inverse is, in general, not true even for T_2-spaces *. A closed set F in the T-space S will be called basic for the moment, if F is the closure of its interior.

Theorem 1. *If the totality of basic closed sets of a T-space S forms a closed basis of S, then the conditions: $R \subset S$ and $\overline{R}^S = S$ imply that $\mathfrak{F}_R$ is a closed framework of S in R.*

In particular, the conditions of Theorem 1 are satisfied if every closed set F in S and a point not belonging to F can be separated by disjoint open sets.

Definition 2. Let S be a T-space, $R \subset S$ and $\mathfrak{B} \subset \mathfrak{F}_R$. We say that the family $\mathfrak{B}$ is Π-separated in S if

$$\overline{\prod_{k=1}^{n} F_k}^S = \prod_{k=1}^{n} \overline{F_k}^S,$$

for any finite system $\{F_k\}_{k=1}^n$ of elements of $\mathfrak{B}$.

---

* This can be seen from the following example. Denote by P the totality of rational points of the real axis E and consider as closed (in E) every set of the form $F+A$, where F is a natural closed set on the axis and A an arbitrary subset of P. The set E with so defined closed subsets is a T_2-space. Put $J = E - P$. If $Q \in \mathfrak{F}_J$ and $P \subset \overline{Q}^E$, then $\overline{Q}^E = E$. But $P \in \mathfrak{F}_E$, therefore $\mathfrak{F}_J$ is not a closed framework of E in J, although $\overline{J}^E = E$.

Let E be a T-space and $\mathfrak{A} \subset \mathfrak{F}_E$. A family X will be called ω-family in $\mathfrak{A}$, if $X \subset \mathfrak{A}$, $X \neq \Lambda$ and the intersection of an arbitrary finite set of elements of X is not empty; we say that X is a maximal ω-family in $\mathfrak{A}$, if X is an ω-family in $\mathfrak{A}$ and is not a proper subset of any ω-family in $\mathfrak{A}$. An ω-family will be called vanishing, if the intersection of all its elements is empty. We say that the T-space E is bicompact if there exist no vanishing ω-families in $\mathfrak{F}_E$.

§ 2. Bicompact Extensions of T-Spaces

Definition 3. Let R be a T-space and $\mathfrak{B}$ a reduced closed basis of R. We say that S is an $(\omega, \mathfrak{B})$-extension of R, if the following conditions are fulfilled: 1) S is a bicompact T-space, 2) R is a subspace of S, 3) $\mathfrak{B}$ is a closed framework of S in R, 4) $\mathfrak{B}$ is Π-separated in S and 5) $(x) \in \mathfrak{F}_S$ whenever $x \in S - R$. We say that S is an ω-extension (or Wallman extension) of R, if S is an $(\omega, \mathfrak{F}_R)$-extension of R.

Theorem 2. *Whatever be the T-space R and its reduced closed basis $\mathfrak{B}$, there exists an $(\omega, \mathfrak{B})$-extension of R.*

This theorem is a generalization of corresponding theorems of H. Wallman [1] and A. Alexandroff [2]. It can be proved by means of the following construction. We denote by $\Omega(\mathfrak{B})$ the totality of vanishing maximal ω-families in $\mathfrak{B}$ and put $\omega_{\mathfrak{B}}(R) = R + \Omega(\mathfrak{B})$. We set

$$\Phi_F = F + \underset{X}{\mathfrak{C}} (X \in \Omega(\mathfrak{B}) \ \& \ F \in X)$$

for every $F \in \mathfrak{B}$. It is easy to see that if $\{F_k\}_{k=1}^n$ is a finite system of elements of $\mathfrak{B}$ and $F = \sum_{k=1}^{n} F_k$, then $\Phi_F = \sum_{k=1}^{n} \Phi_{F_k}$; the T-space $\omega_{\mathfrak{B}}(R)$, determined by the family of all such sets Φ_F considered as a closed basis, satisfies the conditions 1) — 5).

Theorem 3. *The $(\omega, \mathfrak{B})$-extension of the T-space R is unique up to a topological mapping leaving invariant every point of R.*

We give here an outline of the proof. Let S be any $(\omega, \mathfrak{B})$-extension of R. We define for every point $x \in S - R$ the family:

$$\mathfrak{B}(x) = \underset{F}{\mathfrak{C}} (F \in \mathfrak{B} \ \& \ x \in \overline{F}^S).$$

Lemma 1. *$\mathfrak{B}(x)$ is a vanishing maximal ω-family in $\mathfrak{B}$ and $\prod_{F \in \mathfrak{B}(x)} \overline{F}^S = (x)$.*

Lemma 2. *Let $X \in \Omega(\mathfrak{B})$. Then $\prod_{F \in X} \overline{F}^S$ is a one-point set, and if x denotes its unique element, then $x \in S - R$ and $X = \mathfrak{B}(x)$.*

Lemma 3. *Let f be a mapping of the set S into $\omega_{\mathfrak{B}}(R)$ defined as follows: $f(x) = x$ if $x \in R$, and $f(x) = \mathfrak{B}(x)$ if $x \in S - R$. Then f is a one-to-one mapping of S onto $\omega_{\mathfrak{B}}(R)$, and $f(\overline{F}^S) = \Phi_F$, whenever $F \in \mathfrak{B}$.*

Theorem 3 follows immediately from Lemma 3.

Theorem 4. *Let S be an $(\omega, \mathfrak{B})$-extension of the T-space R, $F \in \Delta\mathfrak{B}$ and let $\mathfrak{C}$ be the totality of sets of the form $F \cdot P$, where $P \in \mathfrak{B}$. Then $\overline{F}^S$ is an $(\omega, \mathfrak{C})$-extension of the T-space F (F and $\overline{F}^S$ are here considered as subspaces of R and S, respectively).*

§ 3. Quasi-Bicompact Extensions of T-Spaces

Let E be a T-space and $\mathfrak{A} \subset \mathfrak{F}_E$. A family X will be called a χ-family in $\mathfrak{A}$, if $X \subset \mathfrak{A}$, $X \neq \Lambda$ and the intersection of interiors (with respect to E) of any finite set of elements of X is not empty; we say that X is a maximal χ-family in $\mathfrak{A}$, if X is a χ-family in $\mathfrak{A}$ and is not a proper subset

of any χ-family in $\mathfrak{A}$. *A* χ-family will be called v a n i s h i n g, if the intersection of all its elements is empty.

D e f i n i t i o n 4. We say that the T-space E is q u a s i - b i c o m p a c t if there exist no vanishing χ-families in $\mathfrak{F}_E$.

It is easy to see that a T_2-space E is a quasi-bicompact* if and only if it is H-closed (in the sense of P. S. Alexandroff).

D e f i n i t i o n 5. Let R be a T-space and $\mathfrak{B}$ a reduced closed basis of R. We say that S is a $(\chi, \mathfrak{B})$-e x t e n s i o n of R, if the following conditions are satisfied: 1) S is a quasi-bicompact T-space, 2) R is a subspace of S, 3) $\mathfrak{B}$ is a closed framework of S in R, 4) $\mathfrak{B}$ is Π-separated in S, 5) $(x) \in \mathfrak{F}_S$, whenever $x \in S - R$, 6) $F \in F_S$, whenever $F \in \Delta\mathfrak{B}$ and $F_R = \Lambda$. We say that S is a χ-e x t e n s i o n of R, if S is a $(\chi, \mathfrak{F}_R)$-extension of R.

T h e o r e m 5. *Whatever be the T-space R and its reduced closed basis $\mathfrak{B}$, there exists a $(\chi, \mathfrak{B})$-extension of R.*

This theorem can be proved by means of the following construction. We denote by $X(\mathfrak{B})$ the totality of vanishing maximal χ-families in $\mathfrak{B}$ and put $\chi_{\mathfrak{B}}(R) = R + X(\mathfrak{B})$. We set for each $F \in \mathfrak{B}$

$$\Phi_F = F + \mathop{\mathcal{E}}_{X} (X \in X(\mathfrak{B}) \,\&\, F \in X).$$

It is easy to see that, if $\{F_k\}_{k=1}^n$ is a finite system of elements of $\mathfrak{B}$ and $F = \sum_{k=1}^{n} F_k$, then $\Phi_F = \sum_{k=1}^{n} \Phi_{F_k}$; the T-space $\chi_{\mathfrak{B}}(R)$, determined by the family of all such sets Φ_F considered as a closed basis, satisfies the conditions 1)—6). The proof is based, in particular, upon the following

L e m m a 4. *Let R be a subspace of the T-space S, $\overline{R}^S = S$, $F \in \mathfrak{F}_R$ and $P \in \mathfrak{F}_S$. Then $F_R = R(\overline{F}^S)_S$ and $R \cdot P_R = R \cdot P_S$.*

T h e o r e m 6. *The $(\chi, \mathfrak{B})$-extension of the T-space R is unique up to the topological mapping leaving invariant every point of R.*

The proof of this theorem is analogous to that of Theorem 3. In particular, Lemmas 1, 2 and 3 rest true if we replace the letters «ω» and «Ω» by «χ» and «X». The family $\mathfrak{B}(x)$ is defined exactly as in Theorem 3. To prove that $\mathfrak{B}(x) \in X(\mathfrak{B})$, the property 6) of the $(\chi, \mathfrak{B})$-extension must be used.

T h e o r e m 7. *The $(\omega, \mathfrak{B})$-extension of the T-space R is at the same time a $(\chi, \mathfrak{B})$-extension of R if and only if the following condition is satisfied: every set F such that $F \in \Delta\mathfrak{B}$ and $F_R = \Lambda$ is a bicompact subset of R.*

Theorem 7 can be deduced from the following

L e m m a 5. *Let S be the $(\omega, \mathfrak{B})$-extension of the T-space R and $F \in \Delta\mathfrak{B}$. Then $F \in \mathfrak{F}_S$ if and only if F is a bicompact subset of R.*

§ 4. If $\mathfrak{A}$ is a family of some subsets of the set E, then $E\{\mathfrak{A}\}$ will denote the totality of complements in E of elements of $\mathfrak{A}$. Let E be a T-space; the family $\mathfrak{R}$ will be called an o p e n b a s i s of E (r e d u c e d o p e n b a s i s of E) if $E\{\mathfrak{R}\}$ is a closed basis of E (respectively, reduced closed basis of E).

Let R be a subspace of the T-space S. To every set $G \in \mathfrak{G}_R$ there corresponds uniquely the o p e n e n v e l o p e of G in S, the greatest of the open sets of S, such that their intersection with R is G; it will be denoted by $\eta_S(G)$. It is easy to see that $\eta_S(G) = S - (\overline{R-G})^S$ and that $\eta_S(G \cdot H) = \eta(G) \cdot \eta_S(H)$, whenever $G \in \mathfrak{G}_R$ and $H \in \mathfrak{G}_R$. Let $\mathfrak{R} \subset \mathfrak{G}_R$; we say that the family $\mathfrak{R}$ is an o p e n f r a m e w o r k of the T-space S in the subspace R, if the totality

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* The equality $A_E = E - (\overline{E-A})^E$ that holds for every $A \subset E$ implies that a T-space E is quasi-bicompact if and only if every covering of E by open sets contains a finite system $\{G_k\}_{k=1}^n$ such that $E = \sum_{k=1}^{n} \overline{G}_k^E$.

of open envelopes in S of the elements of $\mathfrak{K}$ is an open basis of S (a family $\mathfrak{K} \subset \mathfrak{G}_R$ is evidently an open framework of S in R if and only if $R\{\mathfrak{K}\}$ is a closed framework of S in R); we say that a family $\mathfrak{K}$ is $\sum$-separated in S, if $\eta_S\left(\sum_{k=1}^{n} G_k\right) = \sum_{k=1}^{n} \eta_S(G_k)$ for any finite system $\{G_k\}_1^n$ of elements of $\mathfrak{K}$ (a family $\mathfrak{K} \subset \mathfrak{G}_R$ is evidently $\sum$-separated in S if and only if $R\{\mathfrak{K}\}$ is H-separated in S).

Theorem 8. *Let R be a T-space and $\mathfrak{K}$ a reduced open basis of R. Then there exists a T-space S with the following properties: 1) S is a bicompact T-space, 2) R is a subspace of S, 3) $\mathfrak{K}$ is an open framework of S in R, 4) $\mathfrak{K}$ is $\sum$-separated in S and 5) if $x \in S - R$, then every point $y \in S$ distinct from x can be separated from x by an open set in S. The T-space S satisfying these conditions is unique up to a topological mapping leaving invariant every point of R. Moreover, S is the $(\omega, R\{\mathfrak{K}\})$-extension of R; conversely, if $\mathfrak{B} \subset \mathfrak{F}_R$ and S is the $(\omega, \mathfrak{B})$-extension of R, then, if we put $\mathfrak{K} = R\{\mathfrak{B}\}$, S possesses all the above properties.*

If we may replace in Theorem 8 the words «bicompact T-space» by a «quasi-bicompact T-space» and add to the conditions 1) — 5) the condition 6): $\eta_S(G) = G + (S - R)$, whenever $G \in \nabla\mathfrak{K}$ and $\bar{G}^R = R$, substituting everywhere «χ» for «ω», we then obtain Theorem 9.

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GEOPHYSICS

ON THE PROBLEM OF LIGHT PROPAGATION IN THE SEA

By E. S. KUZNETZOV

(Communicated by O. J. Schmidt, Member of the Academy, 24. IX. 1942)

The propagation of light in the sea can be described with the help of the approximate equations

$$\left.\begin{aligned} \frac{dF_\nu^{(1)}}{d\tau} &= A_\nu F_\nu^{(1)} + B_\nu F_\nu^{(2)}, \\ \frac{dF_\nu^{(2)}}{d\tau} &= C_\nu F_\nu^{(1)} + D_\nu F_\nu^{(2)} \end{aligned}\right\} \tag{1}$$

where $F_\nu^{(1)}(\tau)$ is the flow of radiant energy of frequency ν, directed downwards, and $F_\nu^{(2)}(\tau)$ — the flow of radiant energy of the same frequency, but directed upwards. As an independent variable in these equations is taken the quantity

$$\tau = \int_0^z \rho(z)\, dz, \tag{2}$$

where $\rho(z)$ is medium density, and z — the depth recorded downwards from the sea surface. Coefficients A_ν, B_ν, C_ν, D_ν are determined by the equations

$$\left.\begin{aligned} A_\nu(\tau) &= -m_\nu^{(1)}(\tau)\,[\alpha_\nu(\tau) + \sigma_\nu(\tau)\,\Gamma_\nu^{(1)}(\tau)], \\ B_\nu(\tau) &= m_\nu^{(2)}(\tau)\,\sigma_\nu(\tau)\,\Gamma_\nu^{(2)}(\tau), \\ C_\nu(\tau) &= -m_\nu^{(1)}(\tau)\,\sigma_\nu(\tau)\,\Gamma_\nu^{(1)}(\tau), \\ D_\nu(\tau) &= m_\nu^{(2)}(\tau)\,[\alpha_\nu(\tau) + \sigma_\nu(\tau)\,\Gamma_\nu^{(2)}(\tau)]. \end{aligned}\right\} \tag{3}$$

Here $\alpha_\nu(\tau)$ stands for the coefficient of absorption. $\sigma_\nu(\tau)$ for the coefficient of scattering, $m_\nu^{(1)}(\tau)$, $m_\nu^{(2)}(\tau)$ for the secants of the mean values of angles ϑ, made up by the directions of the rays with that of the vertical. $m_\nu^{(1)}(\tau)$ corresponding to all the rays for which $0 \leqslant \vartheta \leqslant \frac{\pi}{2}$, and $m_\nu^{(2)}(\tau)$ to all the rays for which $\frac{\pi}{2} \leqslant \vartheta \leqslant \pi$; $\Gamma_\nu^{(1)}(\tau)$, $\Gamma_\nu^{(2)}(\tau)$ are functions depending on the kind of the indicatrix of scattering and referring respectively to the first and the second of the two classes of rays just mentioned. In the case of spherical scattering $\Gamma_\nu^{(1)} = \Gamma_\nu^{(2)} = \frac{1}{2}$; the quantities $\Gamma_\nu^{(1)}$, $\Gamma_\nu^{(2)}$ have the same value in the case of Rayleigh scattering and in general in the case of scattering laws fulfilling some symmetry conditions (1). As an example of an asymmetrical law of scattering may serve the function

$$\frac{1}{1 + \frac{1}{3} g_\nu}\,(1 + p_\nu \cos\varphi + g_\nu \cos^2\varphi),$$

where φ is the angle between the direction of a ray entering the scattering volume and one leaving this volume. In this case

$$\left.\begin{aligned}\Gamma_\nu^{(1)} &= \frac{1}{2}\left[1-\frac{p_\nu}{2m_\nu^{(1)}\left(1+\frac{1}{3}q_\nu\right)}\right],\\ \Gamma_\nu^{(2)} &= \frac{1}{2}\left[1-\frac{p_\nu}{2m_\nu^{(2)}\left(1+\frac{1}{3}q_\nu\right)}\right].\end{aligned}\right\} \tag{4}$$

In the particular case when $\Gamma_\nu^{(1)}=\Gamma_\nu^{(2)}=\Gamma_\nu$ we can put $\sigma_\nu'=2\sigma_\nu\Gamma_\nu$. Then the coefficients A_ν, B_ν, C_ν, D_ν will assume the same shape as in the case of spherical scattering. *Thus, in the case when $\Gamma_\nu^{(1)}=\Gamma_\nu^{(2)}$ non-spherical scattering may be considered a spherical one, except for a changed scattering coefficient.* In the case (4) we obtain conditions $\Gamma_\nu^{(1)}=\Gamma_\nu^{(2)}$, if there is stipulated that $m_\nu^{(1)}=m_\nu^{(2)}=m_\nu$. Then

$$\sigma_\nu'=\sigma_\nu\left[1-\frac{p_\nu}{2m_\nu\left(1+\frac{1}{3}q_\nu\right)}\right]. \tag{5}$$

This formula leads to the reduction of the scattering coefficient, which is the greater, the more sharply pronounced is the asymmetry of the scattering indicatrix.

G. A. Gamburzev [2] was the first to apply equations of type (1) to the problems of sea optics. My note [1] gives a more rigourous and general solution suggesting formulae which serve to connect the quantities $\Gamma_\nu^{(1)}(\tau)$ and $\Gamma_\nu^{(2)}(\tau)$ with the law of scattering.

Gamburzev reduces equations (1) to that suggested by Riccatti for the relation $F_\nu^{(2)}/F_\nu^{(1)}$ (coefficient of reflexion), and gives an approximate solution of this equation; he proceeds from the assumption that the coefficient of reflexion $F_\nu^{(2)}/F_\nu^{(1)}$ may be considered a constant magnitude.

In order to get rid of this a priori non-obvious and not always correct assumption, we shall confine ourselves to the examination of the constant coefficients in equations (1). In this case Riccatti's equation cited by Gamburzev is solved in quadratures, and the constancy of the reflexion coefficient for an infinitely deep sea is deduced as a strict consequence of this solution.

A direct solution of the system (1) may be represented in the form where

$$\left.\begin{aligned}F_\nu^{(1)}(\tau) &= H_1(D_\nu-\lambda_1)e^{\lambda_1\tau}+H_2(D_\nu-\lambda_2)e^{\lambda_2\tau},\\ F_\nu^{(2)}(\tau) &= -H_1C_\nu e^{\lambda_1\tau}-H_2C_\nu e^{\lambda_2\tau}\end{aligned}\right\} \tag{6}$$

H_1 and H_2 are arbitrary constants, and λ_1 and λ_2 are roots of the equation

$$\lambda^2-(A_\nu+D_\nu)\lambda+A_\nu D_\nu-C_\nu B_\nu=0. \tag{7}$$

The solution of this equation gives

$$\left.\begin{aligned}\lambda_1 &= \frac{A_\nu+D_\nu}{2}+\Omega_\nu, \qquad \lambda_2=\frac{A_\nu+D_\nu}{2}-\Omega_\nu,\\ \Omega_\nu &= \sqrt{\left(\frac{A_\nu+D_\nu}{2}\right)^2-(A_\nu D_\nu-C_\nu B_\nu)}.\end{aligned}\right\} \tag{8}$$

By virtue of inequality

$$A_\nu D_\nu-B_\nu C_\nu=-m_\nu^{(1)}m_\nu^{(2)}\alpha_\nu[\alpha_\nu+\sigma_\nu(\Gamma_\nu^{(1)}+\Gamma_\nu^{(2)})]<0$$

we always have

$$\lambda_1>0, \qquad \lambda_2<0. \tag{9}$$

The initial conditions should be formulated in a different way according as the case considered is a sea of a finite or infinite depth.

In the former case flow $F_\nu^{(1)}(\tau)$ must assume the known value $F_\nu^{(1)}(0)$ with $\tau = 0$, while flow $F_\nu^{(2)}(\tau)$ [and $F_\nu^{(1)}(\tau)$] must remain bounded if $\tau \to \infty$. These assumptions lead us to the following values of the arbitrary constants

$$H_1 = 0, \quad H_2 = \frac{F_\nu^{(1)}(0)}{D_\nu - \lambda_2}. \tag{10}$$

Consequently

$$F_\nu^{(1)}(\tau) = F_\nu^{(1)}(0)\, e^{\lambda_2 \tau}, \quad F_\nu^{(2)}(\tau) = -\frac{C_\nu F_\nu^{(1)}(0)}{D_\nu - \lambda_2}\, e^{\lambda_2 \tau}. \tag{11}$$

Hence for the coefficient of reflexion we obtain

$$Q = \frac{F_\nu^{(2)}}{F_\nu^{(1)}} = -\frac{C_\nu}{D_\nu - \lambda_2} = \text{const}. \tag{12}$$

Thus, in the case of an infinitely deep sea the coefficient of reflexion has the same value for any depth.

Making good use of (8) we receive for Q_ν a more detailed expression

$$Q_\nu = -\frac{2C_\nu}{D_\nu - A_\nu + \sqrt{(A_\nu + D_\nu)^2 - 4(A_\nu D_\nu - C_\nu B_\nu)}}. \tag{13}$$

Substituting the coefficients A_ν, B_ν, C_ν, D_ν from (3) we finally have

$$Q_\nu = \frac{2m_\nu^{(1)} \sigma_\nu \Gamma_\nu^{(1)}}{m_\nu^{(1)} + m_\nu^{(2)}} : \left\{ \alpha_\nu + \sigma_\nu \frac{m_\nu^{(1)} \Gamma_\nu^{(1)} + m_\nu^{(2)} \Gamma_\nu^{(2)}}{m_\nu^{(1)} + m_\nu^{(2)}} + \right.$$

$$\left. + \sqrt{\sigma_\nu^2 \left(\frac{m_\nu^{(1)} \Gamma_\nu^{(1)} - m_\nu^{(2)} \Gamma_\nu^{(2)}}{m_\nu^{(1)} + m_\nu^{(2)}} \right)^2 + 2\alpha_\nu \sigma_\nu \frac{m_\nu^{(1)} \Gamma_\nu^{(1)} + m_\nu^{(2)} \Gamma_\nu^{(2)}}{m_\nu^{(1)} + m_\nu^{(2)}} + \alpha_\nu^2} \right\}. \tag{14}$$

Let us note some particular cases:

1° $m_\nu^{(1)} = m_\nu^{(2)}$.

$$Q_\nu = \frac{\sigma_\nu \Gamma_\nu^{(1)}}{\alpha_\nu + \sigma_\nu \frac{\Gamma_\nu^{(1)} + \Gamma_\nu^{(2)}}{2} + \sqrt{\sigma_\nu^2 \left(\frac{\Gamma_\nu^{(1)} - \Gamma_\nu^{(2)}}{2} \right)^2 + 2\sigma_\nu \alpha_\nu \frac{\Gamma_\nu^{(1)} + \Gamma_\nu^{(2)}}{2} + \alpha_\nu^2}}. \tag{15}$$

2°. $\Gamma_\nu^{(1)} = \Gamma_\nu^{(2)} = \Gamma_\nu$.

$$Q_\nu = \frac{\frac{2m_\nu^{(1)}}{m_\nu^{(1)} + m_\nu^{(2)}} \Gamma_\nu \sigma_\nu}{\alpha_\nu + \sigma_\nu \Gamma_\nu + \sqrt{\sigma_\nu^2 \Gamma_\nu^2 \left(\frac{m_\nu^{(1)} - m_\nu^{(2)}}{m_\nu^{(1)} + m_\nu^{(2)}} \right)^2 + 2\sigma_\nu \alpha_\nu \Gamma_\nu + \alpha_\nu^2}}. \tag{16}$$

3°. $m_\nu^{(1)} = m_\nu^{(2)}$; $\Gamma_\nu^{(1)} = \Gamma_\nu^{(2)} = \Gamma_\nu$.

$$Q_\nu = \frac{\sigma_\nu \Gamma_\nu}{\alpha_\nu + \sigma_\nu \Gamma_\nu + \sqrt{\alpha_\nu (\alpha_\nu + 2\sigma_\nu \Gamma_\nu)}}. \tag{17}$$

4°. $m_\nu^{(1)} = m_\nu^{(2)}$; $\Gamma_\nu^{(1)} = \Gamma_\nu^{(2)} = \frac{1}{2}$.

$$Q_\nu = \frac{\frac{1}{2}\sigma_\nu}{\alpha_\nu + \frac{1}{2}\sigma_\nu + \sqrt{\alpha_\nu (\alpha_\nu + \sigma_\nu)}}. \tag{18}$$

For the case of a sea of finite depth let us put

$$\left.\begin{aligned} F_\nu^{(1)}(\tau) &\to F_\nu^{(1)}(0) \quad \text{when } \tau \to 0, \\ F_\nu^{(2)}(\tau^*) &= F_\nu^{(1)}(\tau^*)\, Q_\nu^* \quad \text{when } \tau = \tau^* \end{aligned}\right\} \tag{19}$$

where Q_ν^* is the albedo of the bottom, $\tau^* = \int_0^h \rho(z)\,dz$ and h - the depth of the sea. Defining H_1, H_2 from (19) and substituting into (6), we obtain

$$\left.\begin{aligned} F_\nu^{(1)}(\tau) &= F_\nu^{(1)}(0)\, e^{\frac{A_\nu + D_\nu}{2}\tau} \frac{\mathfrak{Q}_\nu \operatorname{ch}\mathfrak{Q}_\nu(\tau^* - \tau) + \left(\frac{D_\nu - A_\nu}{2} - B_\nu Q_\nu^*\right)\operatorname{sh}\mathfrak{Q}_\nu(\tau^* - \tau)}{\mathfrak{Q}_\nu \operatorname{ch}\mathfrak{Q}_\nu \tau^* + \left(\frac{D_\nu - A_\nu}{2} - B_\nu Q_\nu^*\right)\operatorname{sh}\mathfrak{Q}_\nu \tau^*} \\ F_\nu^{(2)}(\tau) &= F_\nu^{(1)}(0)\, e^{\frac{A_\nu + D_\nu}{2}\tau} \frac{Q_\nu^* \mathfrak{Q}_\nu \operatorname{ch}\mathfrak{Q}_\nu(\tau^* - \tau) - \left(\frac{D_\nu - A_\nu}{2} Q_\nu^* + C_\nu\right)\operatorname{sh}\mathfrak{Q}_\nu(\tau^* - \tau)}{\mathfrak{Q}_\nu \operatorname{ch}\mathfrak{Q}_\nu \tau^* + \left(\frac{D_\nu - A_\nu}{2} - B_\nu Q_\nu^*\right)\operatorname{sh}\mathfrak{Q}_\nu \tau^*} \end{aligned}\right\} \tag{20}$$

Hence

$$Q_\nu(\tau) = \frac{\mathfrak{Q}_\nu Q_\nu^* \operatorname{ch}\mathfrak{Q}_\nu(\tau^* - \tau) - \left(\frac{D_\nu - A_\nu}{2} Q_\nu^* + C_\nu\right)\operatorname{sh}\mathfrak{Q}_\nu(\tau^* - \tau)}{\mathfrak{Q}_\nu \operatorname{ch}\mathfrak{Q}_\nu(\tau^* - \tau) + \left(\frac{D_\nu - A_\nu}{2} - B_\nu Q_\nu^*\right)\operatorname{sh}\mathfrak{Q}_\nu(\tau^* - \tau)}. \tag{21}$$

Let us mention some particular cases of bottom albedo Q_ν^*:
1) If $Q_\nu^* = 0$, then

$$Q_\nu(\tau) = \frac{-C_\nu \operatorname{sh}\mathfrak{Q}(\tau^* - \tau)}{\mathfrak{Q}_\nu \operatorname{ch}\mathfrak{Q}_\nu(\tau^* - \tau) + \frac{D_\nu - A_\nu}{2}\operatorname{sh}\mathfrak{Q}_\nu(\tau^* - \tau)} \tag{22}$$

which for $\tau = 0$ gives

$$Q_\nu(0) = \frac{-2C_\nu}{D_\nu - A_\nu + 2\mathfrak{Q}_\nu \operatorname{cth}\mathfrak{Q}_\nu \tau^*}. \tag{23}$$

2) If $Q_\nu^* = \frac{-2C_\nu}{D_\nu - A_\nu + 2\mathfrak{Q}_\nu}$, then

$$Q_\nu(\tau) = \frac{-2C_\nu}{D_\nu - A_\nu + 2\mathfrak{Q}_\nu} = \text{const},$$

i. e. if the bottom albedo has a value equal to the coefficient of reflexion of an infinitely deep sea, then in a sea of a finite depth the reflexion coefficient has everywhere the same magnitude equal to its value at the bottom. This case has already been pointed out by Gamburzev.

3) If $Q_\nu^* = \frac{-2C_\nu}{D_\nu - A_\nu - 2\mathfrak{Q}_\nu \operatorname{cth}\mathfrak{Q}_\nu \tau^*}$, then $Q_\nu(0) = 0$.

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TECHNICAL PHYSICS

A SIMPLE METHOD FOR CALCULATING COMPLEX PERMEABILITY

By V. K. ARKADIEV, Corresponding Member of the Academy, and C. M. POLIVANOV

Calculation of complex permeability of matter $\mu - i\rho'$ from experimental data necessitates, in the general case of neither too great nor too small a skin-effect, the use of special diagrams which for the electric skin-effect have been constructed by Wwedensky (1); for the magnetic one, by Arkadiev (2). Accordingly, in one case the determination is made from the experimentally obtained resistance to direct current, R_0, and to alternating current, R, and from the inner inductance ωL_i; while in the other case it is made from the average permeability of the body taken over its cross-section, that is, from conservative, μ_1, and consumptive, μ_2, permeability. The first kind of diagram is designed to perform the calculation from the coordinates $A_e = \frac{R}{R_0}$ and $B_e = \frac{\omega L_i}{R_0}$; the second is used after a preliminary calculation of the coordinates $F_m = \mu_1 x_1^2$ and $G_m = \mu_2 x_1^2$, where x_1 is a coefficient depending upon conductivity, dimensions of the sample, and the field frequency.

C. M. Polivanov (3) has called attention to the fact, that no use of special diagrams is necessary any longer if the four values A_e, B_e, μ_1 and μ_2 are known from the experiment.

A simple formula will then suffice to compute the real and imaginary components of the permeability of matter, since it turns out that

$$\mu - i\rho' = (A_e + iB_e)(\mu_1 - i\mu_2).$$

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BIOPHYSICS

MAGNITUDE OF THE THRESHOLD OF STEREOSCOPIC VISION AS AFFECTED BY THE PERIOD OF OBSERVATION

By L. N. GASSOVSKY and N. A. NIKOLSKAYA

(Communicated by S. I. Wawilow, Member of the Academy, 3.X.1942)

1. The problem as to the effect of the length of observation upon the magnitude of the threshold of stereoscopic vision should be classed among those but scarcely discussed in literature. Only in three papers out of those we are acquainted with[1-5] the threshold of stereoscopic vision was determined under conditions of a restricted period of observation.

To find out the nature of the relation existing between the magnitude of the threshold of stereoscopic vision and that of the period of observation would be of great interest not only from the theoretical, but from the practical point of view as well, since on the faculty of the eye to evaluate the mutual arrangement of bodies according to depth has been based the design of a number of optical instruments, in particular of stereo-telemeters.

The ability of one who is working with a stereo-telemeter is appraised not only according to the magnitude of his threshold of stereoscopic vision for an unlimited period of observation, but also according to the values of this threshold for short periods of observation corresponding to the high speed of his work.

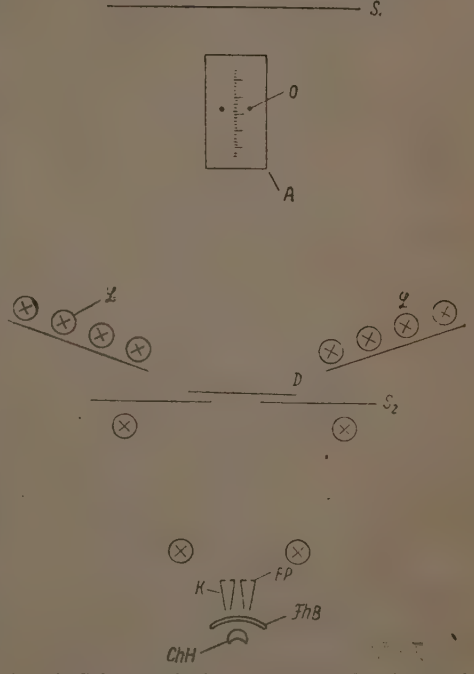

Fig. 1. Scheme of the experimental set-up: *A*, apparatus for determining the threshold of stereoscopic vision; *O*, objects of observation; S_1 and S_2, screens; *D*, shutter; *L*, illuminating lamps; *K*, cones; *FP*, frosted plate; *ChH* and *FhB*, chin-holder with forehead bow.

In this connexion the question dealing with the relation between the magnitude of the threshold of stereoscopic vision and the length of observation becomes still more important both for designing stereo-telemeters and for an adequate selection of persons apt to handle these instruments under field conditions. Such have been the considerations that made us undertake the present study.

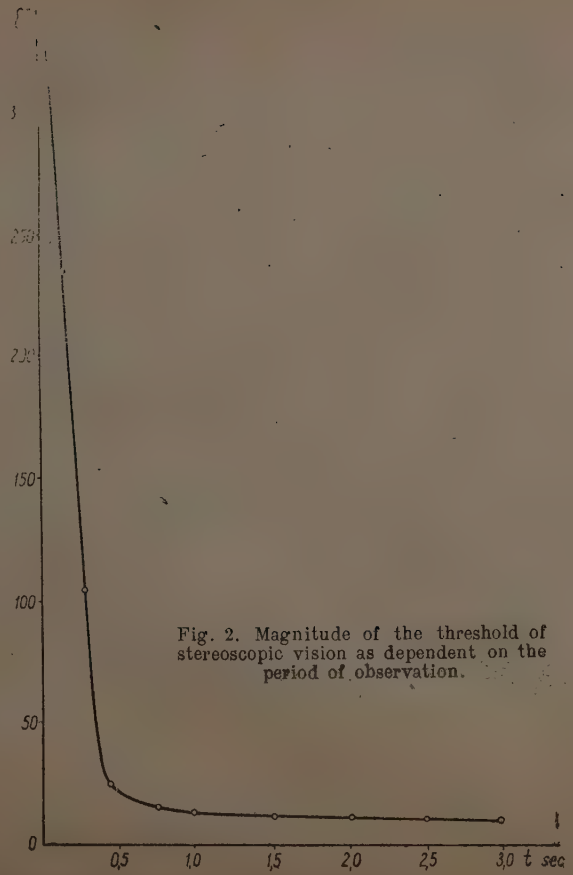

Fig. 2. Magnitude of the threshold of stereoscopic vision as dependent on the period of observation.

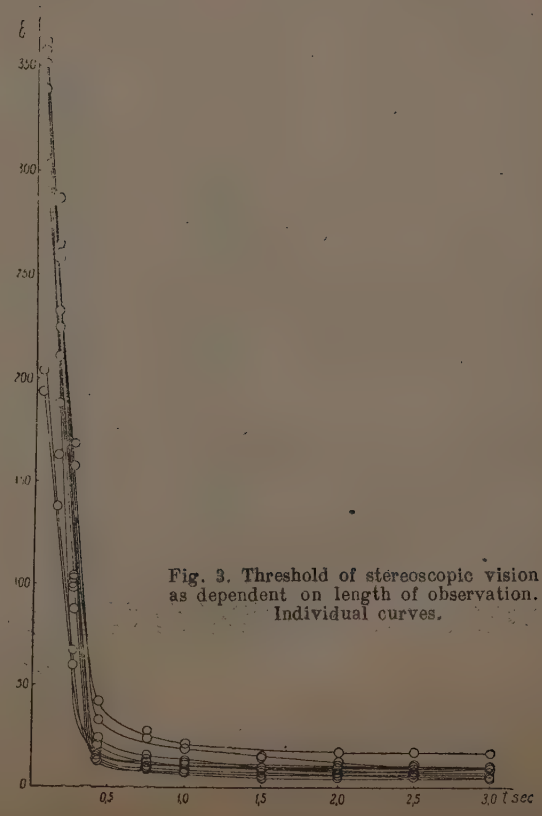

Fig. 3. Threshold of stereoscopic vision as dependent on length of observation. Individual curves.

2. The set-up which served for the present work consisted in the main (Fig. 1) of an instrument A which made it possible to shift along the line of vision of the spectator two vertical black cylindrical rods O. The rods were 3′ across, and 10′ apart in the transverse direction: they were moved along a scale whose zero division was at a distance of 5.25 m from the spectator's eye. Behind the instrument was placed a screen S_1 against whose background the rods were visible to the spectator. The spectator was separated from the instrument by another screen S_2. This had in its centre an aperture whose height, serving to determine the height of the rods as perceived by the spectator, was equal to 75′ against a width of 150′. The aperture of the screen was

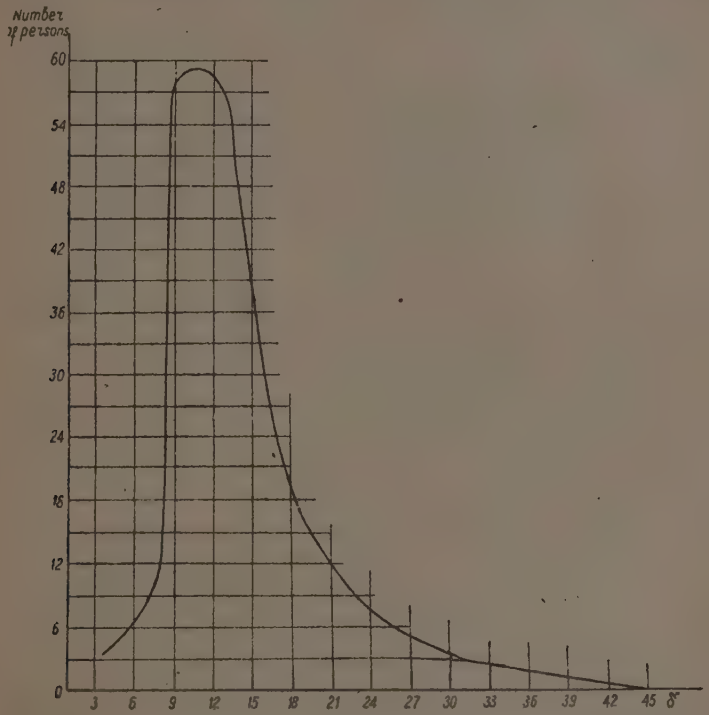

Fig. 4. Distribution of values of threshold of stereoscopic vision with $t=2.0$ sec.

opened or closed with the aid of a special shutter D. This shutter made it possible to leave the aperture open for a period of 0.05, 0.15, 0.26, 0.46, 0.75, 1.0, 1.5, 2.0, 2.5 or 3.0 seconds.

The spectator was seated in front of the instrument at a table upon which were put a chin-holder ChH with a forehead bow FhB attached to it and a contrivance for illuminating the retina. The latter consisted of two cones K with a silver-plated inner surface, in whose wide openings were inserted the plates FP made of frosted glass and having round apertures in the centre. Through these apertures the spectator could view the rods against the background of the screens S_1 and S_2. The screens and the frosted plates of the cones were regularly illuminated by the lamps L in such a manner as to enable the spectator to view an uninterrupted white field of a brightness 0.018 sb. In order that the experiment could be started with a given adaptational level of the eye equal for any spectator, the latter, after all the necessary preparations to the test had been performed, was invited to look during 5—10 minutes without interruption through the cone

at the screen S_2 . For erery value of observation time there was measured the least displacement of the rods by depth as could be recorded by the spectator. This separation of the rods was considered as magnitude of the threshold of the stereoscopic vision.

To convert the linear value of the threshold into its angular value, the following formula was made use of:

$$\delta = \frac{b\Delta D}{D^2} 206\,000,$$

where δ is the threshold of stereoscopic vision in angular seconds; b, the distance between the pupils of the spectator; ΔD, the linear value of the

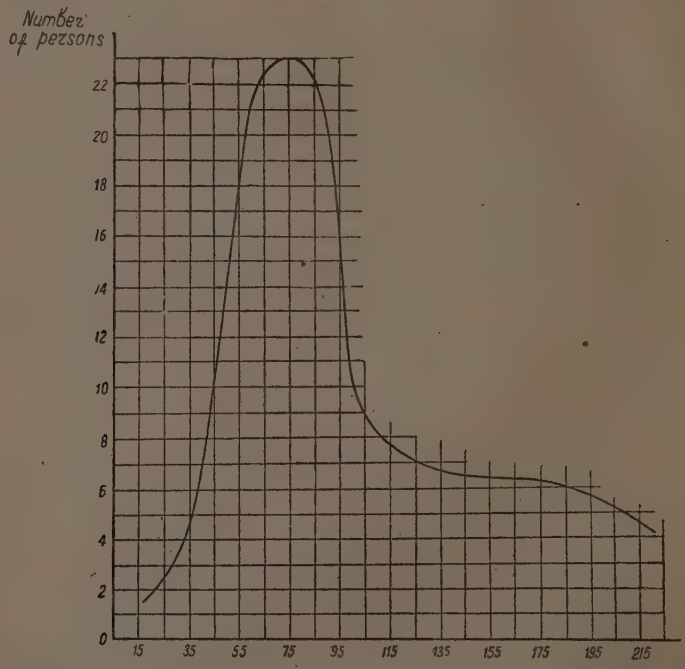

Fig. 5. Distribution of values of threshold of stereoscopic vision with $t=0.26$ sec.

threshold; D, the distance between the test-object and the spectator; 206000 is the number of angular seconds in the radian.

The tests embraced 11 spectators showing ametropia within the range of ± 0.5 dioptrics, endowed with a faculty of vision not below 0.9 and a beterophoria within the range of $\pm 2\Delta$. Each spectator was tested in the course of three experimental days which were preceded by one training day.

3. The results of the study are represented in the shape of a curve in Fig. 2. From this curve it may be seen to what extent the mean magnitude of the threshold of stereoscopic vision for all the eleven spectators depends on the period of observation. Along the horizontal axis are plotted the magnitudes of the periods of observation t in sec., along the vertical axis—the corresponding values of the threshold of stereoscopic vision δ in angular seconds. As seen from this figure, a reduction of the period of observation from 3.0 sec. to 1.5 sec. does not practically affect the magnitude of the threshold of stereoscopic vision; if one proceeds to shorten the period of observation (down to 0.46 sec.), the thre-

shold starts to increase; if the period of observation is made still shorter (down to 0.05 sec.), the magnitude of the threshold goes on growing very rapidly. Fig. 3 shows individual curves for each of the 11 spectators. From this figure it may be seen that the run of the curves is almost the same in all cases: the individual deviations from the general run of the curves are insignificant; there are but two curves (the left-hand ones) plotted for two persons working at this laboratory, who have acquired a rather considerable skill in observation, that show a relatively small ordinate against a $t=0.05$ sec.

We have also measured for 205 cases the threshold of stereoscopic vision with two values of the exposure, $t=2.0$ sec. and $t=0.26$ sec. According to Fig. 2, the exposure of 2.0 sec. corresponds to those medium values for which the magnitude of the threshold of stereoscopic vision is practically independent of the period of observation. If the exposure lasts 0.26 sec., the threshold of stereoscopic vision assumes rather large values.

Figs. 4 and 5 show curves of distribution of the magnitudes of the threshold of stereoscopic vision δ for $t=2.0$ sec. and $t=0.26$ sec. for 205 spectators. These curves show that with a $t=2.0$ sec. most of the spectators display a threshold of stereoscopic vision equal to 9—12 sec.; the mean value of the threshold calculated for all the spectators equals in this case 18.5 sec. With $t=0.26$ sec. the threshold of stereoscopic vision equals in the majority of spectators 65—85 sec., i. e. is 6—8 times larger.

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CHEMISTRY

CONTINUOUS TRANSITION BETWEEN THE DALTONIDE AND THE BERTHOLLIDE PHASES IN THE SYSTEM IRON-NICKEL-ANTIMONY

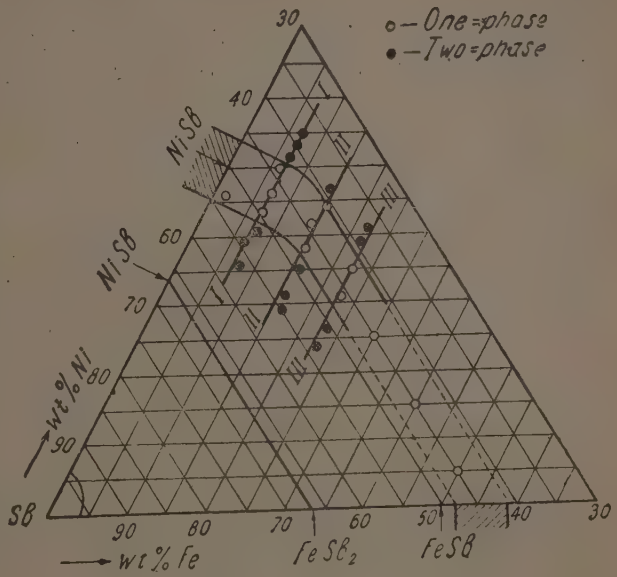
By N. W. AGEEW and E. S. MAKAROV

(Communicated by V. G. Chlopin, Member of the Academy, 20.VIII.1942)

According to N. S. Kurnakov (2), a berthollide can be considered as a phase, based on a chemical compound of definite composition unstable at its stoicheiometric ordinate. Experimentally this point of view has been supported by means of X-ray methods on many examples (2). In particular, Hägg (3) has demonstrated that the ε-phase in the system iron-antimony within 44—46.5 atomic % of Sb, has the structure of a nickel-arsenide type where in the space lattice of the compound Fe_2Sb_2 extra iron atoms are inserted. This made N. S. Kurnakov (4) suppose that the addition of nickel to iron-antimony alloys gives the possibility to move the imaginary ordinate Fe_2Sb_2 into the area of real stable composition, because the corresponding phase with the nickel-arsenide structure in the system nickel-antimony is by its character a daltonide one.

Below a brief report is given of the results of an experimental study (5) of the problem of continuous transition between the berthollide phase ε of the system iron-antimony and the daltonide phase of the system nickel-antimony both with nickel arsenide structure. The alloys were prepared from electrolytic iron, nickel and antimony homogenised at 600° during 3 days and slowly cooled to room temperature. First of all, the determinations were made of the boundary within which nickel-arsenide phases exist in binary systems nickel-antimony and iron-antimony. Their crystalline structure has also been established, as well as the properties within the homogeneity of the phase. Data on microstructure, electroconductivity, its temperature coefficient and lattice parameters, in good agreement with one another, served to prove that in the system nickel-antimony the nickel-arsenide phase exists within 46.4—54.4 at. % of Sb. This phase is characterized by the singular point corresponding to the composition NiSb on the isotherms of electroconductivity, of its temperature coefficient and of hardness. According to data obtained by the same methods, in the system iron-antimony the corresponding phase exists within 42.0—48.0 at. % of Sb, and is characterized by a gradual change in properties within homogeneity. By comparing data on density with the volume of elementary cell and by measuring the intensity of reflection on the powder photographs, the authors came to the conclusion that the alloys of the system nickel-antimony, containing an excess of nickel compared to the composition NiSb, are built according to the type of interstitial solid solutions, as in the case of the iron-antimony alloy studied by Hägg (3). In the system nickel-antimony, the alloys lying in the area rich in antimony from the ordinate of the compound NiSb, are built according to the type of solid solutions with a defect lattice, characterized by the absence of a certain number of atoms at the points of the crystalline lattice (5, 6).

In order to find out whether there exists a continuous area of solid solutions between the nickel arsenide phases of the systems nickel-antimony and iron-antimony when a ternary system iron-nickel-antimony is formed. the authors have prepared and studied alloys, the composition of which is shown in the figure. The data on microstructure, electroconductivity and on lattice parameter show quite definitely the presence of a continuous series of ternary solid solutions and give the possibility to fix the boundary of their existence, as shown in the figure. All the ternary alloys studied have the structure of the nickel-arsenide type. Just as in binary systems, the crystalline lattice of ternary homogeneous alloy, which contain the excess of iron and nickel in respect to the rational section NiSb—FeSb, is built according to the interstitial type, while the alloys with the excess of antimony have a defect lattice.



The formation of a continuous series of solid solutions betwen two isomorphous phases, one of which is a daltonide and the other a berthollide (as is the case with the system investigated), is a very representative instance of a continuous transition from daltonides to berthollides and points to the common genetic nature of these compounds.

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CHEMISTRY

IMPROVEMENT OF MIRZAAN GASOLINE BY MEANS OF CATALYTIC DEHYDROGENATION*

By Kh. I. ARESHIDZE

(Communicated by N. D. Zelinsky, Member of the Academy, 27.VI.1942)

The construction of modern internal combustion engines makes it necessary for the oil industry to produce high grade gasoline. Gasoline with a high octane number increases the efficiency of the engine and lengthens its working period. Therefore the increase of antiknock properties of gasoline is a problem of considerable practical importance.

The author's aim was to increase the octane number of Mirzaan gasoline by converting hydroaromatic hydrocarbons into aromatic ones according to N. D. Zelinsky ([1]). Some unpublished observations made by me in collaboration with Ayvazov and Krikhel have shown that the fraction 60—95° C of Mirzaan gasoline contains 12% of hydroaromatic hydrocarbons. Thereby was opened the possibility to improve Mirzaan gasoline through catalytic dehydrogenation. Our purpose being to achieve a complete dehydrogenation of hydroaromatic hydrocarbons rather than their identification, the gasoline was subjected to catalytic treatment without a preliminary elimination of aromatic hydrocarbons. Platinum deposited on activated charcoal and prepared according to Zelinsky and Turova-Poliak ([2]) was used as a catalyst. The activity of the catalyst was checked by passing cyclohexane at 310° through a tube containing the catalyst in a feeble current of hydrogen. The amount of cyclohexane dehydrogenated (% by weight) was determined refractometrically accordind to Pavlov ([3]).

The catalyst was placed in a glass tube 1.8 cm in diameter and 82 cm long (length of catalyst layer 20 cm, weight 8 g). The tube was heated in an electric stove. The receiver and the trap were cooled with a solution of solid carbon dioxide in alcohol.

Dehydrogenation was carried out at 305—310° in a feeble current of hydrogen and was considered complete when further passage of the gasoline no longer increased the refractive index of the condensate. Then the activity of the catalyst was again checked and proved to be the same as before the run.

The refractive index, specific weight, boiling point and the content of aromatics (% by volume) of the gasoline before and after catalytic treatment may be seen from the table.

The content of aromatics both before and after catalytic treatment was determined in a glass cylinder with a ground stopper graduated up to 0.1 cm^3 by means of the Kattwinkel reagent ([4]). Complete elimination of aromatics was checked through repeated sulphuration.

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* Presented before the session of the Academy of Sciences of the Georgian SSR, 29 April, 1942.

n_D^{23}		d_4^{20}		Boiling point		Content of aromatics, % by volume	
Before catalysis	After catalysis	Before catalysis	After catalysis	Before catalysis $p=729$ mm	Arter catalysis $p=734$ mm	Before catalysis	After catalysis
1.4050	1.4276	0.7294	0.7551	33—150°	40—160°	7.78	36.84

As a result of the aromatization of Mirzaan gasoline the content of aromatics increased by 29.06% (by volume).

Fraction 40—139° of Ural gasoline (Chussovsky Gorodki), according to Zelinsky and Yuriev[5], contained 33% of aromatic hydrocarbons, and after catalytic dehydrogenation this figure increased by 25%.

Thus, although the Ural gasoline is richer in aromatics compared to the Mirzaan gasoline, the latter contains more hydroaromatic hydrocarbon. As a result of aromatization the octane number of the Mirzaan gasoline increased by as much as 7 points.

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CHEMISTRY

INFLUENCE OF SALT ADMIXTURES UPON DISSOCIATION OF DOLOMITE

By L. G. BERG

(Communicated by V. G. Chlopin, Member of the Academy, 28.VII.1942)

What invites our attention in studying the thermal dissociation of dolomites is the diversified character of their thermograms. Examination of a great number of thermograms obtained with different samples of natural dolomites has shown that they can be divided into two substantially different types of curve. In one case the first endothermic effect appears suddenly at about 730° C, the temperature of the sample dropping by 5 to 20° C, which fact is reflected on the thermograms in the form of a sharply expressed «wave» of superheating (Fig. 1). In other cases dolomite begins to dissociate at considerably lower temperatures, no superheating wave being observed on the curve.

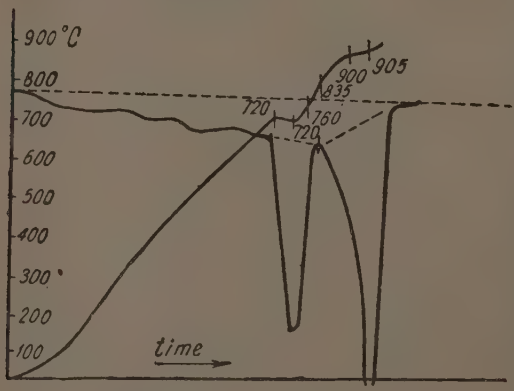

Fig. 1. Thermogram of the Shishima dolomite.

Palitzyn [1] explains the variations in the dissociation temperature of dolomite by the degree of its recrystallization and its capability to form solid solutions with calcium carbonate, as well as with magnesium carbonate. According as the former or latter is present in the solid solution, the dissociation point of dolomite goes up or down.

A much more simple way to explain the presence of the superheating wave in the thermogram is by ascribing it to a preliminary dissociation of dolomite at 730° C into free calcium and magnesium carbonates. The latter then immediately dissociates into MgO and CO_2 with great speed and with reduction of temperature, because the dissociation pressure of $MgCO_3$ at 730° is well above the atmospheric pressure.

Contrary to this, the absence of the superheating wave on the curve and a much lower point of dissociation are indicative of a dolomite that is readily broken down. This cannot be interpreted satisfactorily in terms of the recrystallization degree alone.

Further inquiry into the matter has revealed that the first type of dolomite, that is the one that gives a superheating wave in the thermograms, may easily

be made to give on the heating curve a picture of second type dissociation. In fact an addition of about 1% of sodium chloride to the sample of dolomite completely suppressed the superheating wave and lowered the dissociation point down to 490—520° C* (Fig. 2).

In certain cases the thermogram of such a mixture reminds of the heating curve of a mixture of calcite with magnesite, since the temperature of the first effect is 600° and of the second 900°. It has further been found that even as small additions of sodium chloride as some tenth and hundredth parts of a per cent do not fail to affect the character of the heating curve of dolomite.

Similar effect upon the dissociation of dolomite have also nitrates, carbonates, acetates of sodium, potassium and a number of other salts of alkaline metals.

It was only natural to infer from these facts that for many samples of natural dolomite the lowering of the dissociation point is due to the presence of some salt, viz. of sodium chloride. Chemical analyses of a great number of dolomites have shown small amounts of chlorides present in many of them. In the thermograms taken from these samples the first endothermic effect was never accompanied bya superheating wave; and conversely, when the latter was present, no chloride was found in the dolomite.

We have also succeeded to show on a number of samples of dolomite from the Ishimbaevo deposit that a careful washing of samples prior to heating, in order to remove any traces of chlorides, is apt to increase the temperature of the first endothermic effect, the character of the thermogram approaching that of the first type (Fig. 3).

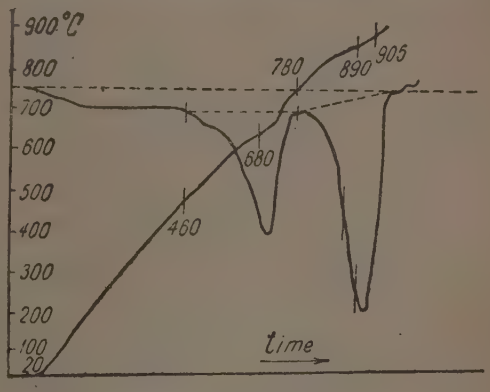

Fig. 2. Thermogram of the Shishima dolomite with 1% NaCl.

This effect is not attained in all cases, however, and some samples of dolomite were observed even after thorough washing to give a diffused first effect on their thermograms. This must be taken to mean that either these dolomites differed virtually from the others, by containing, for instance, some admixture of calcite and magnesite in the form of a solid solution, or they simply included some foreign admixture insoluble in water but, like alkaline metal salts, having an influence upon the dissociation process. An example of that sort of dolomite is furnished by the so-called sugar-like dolomite from the region of Samarskaya Luka. Careful treatment of this dolomite with water did not noticeably change the character of its thermogram (Fig. 4). It is of interest to point out that some experiments on its solubility in water, saturated with carbon dioxide**, have shown that it is almost two and a half times as soluble as, for instance, the very pure marble-like Shishima dolomite which gave a high superheating wave on the thermogram.

In the case of quantitative phase analysis ([2], [3]) by means of thermographic method the relative content of calcite, dolomite and magnesite may be determined from the ratio of the areas reproduced by the differential record. The change in the character of the curves on the thermograms due to admixture of salts should, naturally, affect the accuracy of the calculations, since it has been observed with dolomite that the temperature of the maximum decomposition effect and of the dissociation of magnesium carbonate varies according to the amount of the admixed salt, ranging from 760—800° to 580—600°.

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* Addition of 1% of sodium chloride to pure magnesite lowers its dissociation point from 500—620° to 420—540° C.

** The experiments and analyses with sugar-like dolomite have been carried out by N. V. Soloviev in the Institute for Geology, Academy of Sciences of the USSR.

As is well known, the heat of dissociation of magnesium carbonate is liable to change considerably (4) in accordance with the temperature of dissociation; thus, when the temperature of this reaction goes down from 800 to 600°, its heat is increased by 2.5 cal. per mol. Naturally enough, the ratio of areas should decrease with decreasing temperature*.

Therefore, some special experiments have been carried out to study the influence of sodium chloride admixtures upon the ratio of the effects of dolomite. For the experiments the marble-like Shishima dolomite has been taken. Its ratio of areas

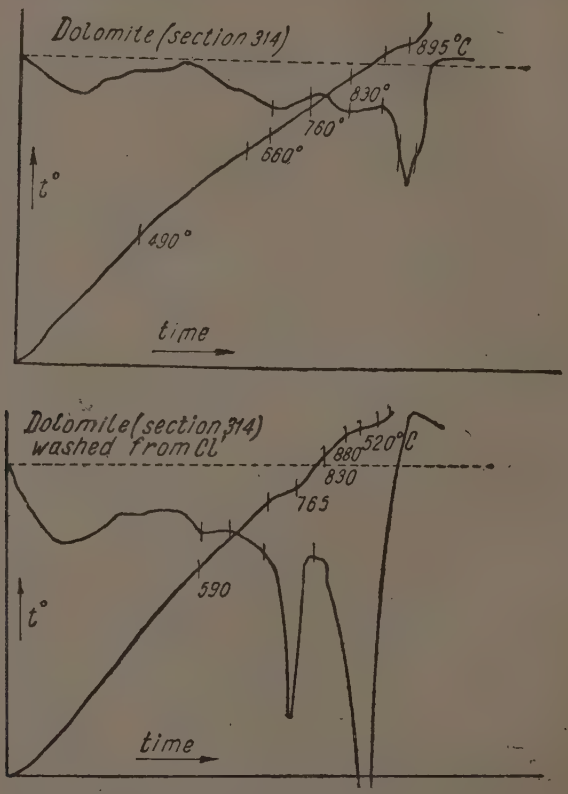

Fig. 3. Thermogram of a natural dolomite unwashed and washed from Cl'.

S_c/S_d is 1.6, where S_c is the area on the differential curve corresponding to the dissociation of calcium carbonate (900°), and S_d is the area corresponding to the decomposition of dolomite and to the subsequent dissociation of the resulting magnesium carbonate (730°).

The experiments resulted in establishing the fact that the addition of sodium chloride to the sample of dolomite actually changes the ratio of areas within wide limits (for Shishima dolomite from 1.6—1.7 to 1.2—1.3).

The temperature dependence of the formation of dolomite from the carbonates has not been studied, but it is certainly too small to have any marked effect upon this ratio.

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* The admixtures have no effect upon the dissociation point of calcium carbonate.

Thus, the admixture of alkaline metal salts sharply alters the character of the thermogram of olomite; so much so, indeed, that erroneous decisions areapt to be made as to the absence or presence, and of how much of free magnesite or calcite in the dolomite. Hence, for quantitative calculations based on measure-

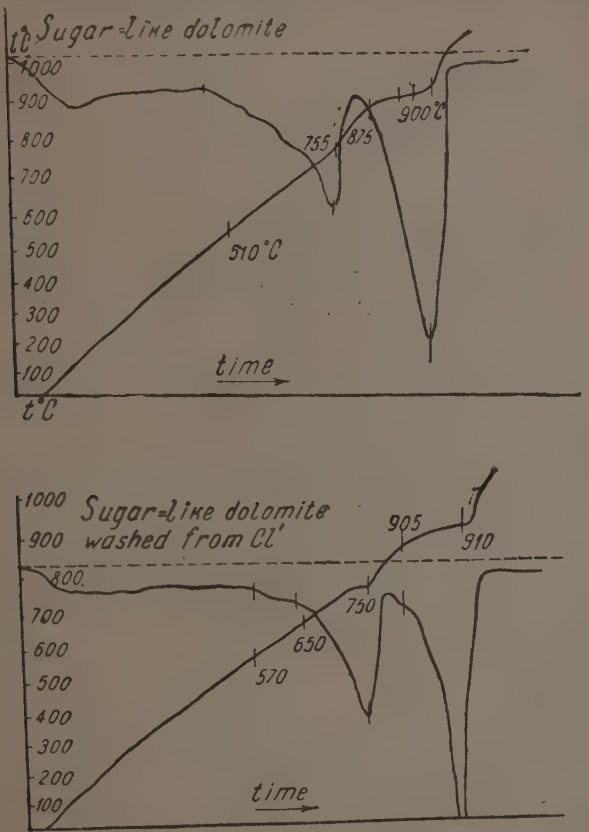

Fig. 4. Thermogram of sugar-like dolomite unwashed and washed from Cl′.

ment of the areas and on determination of their ratio, it is essential to pay attention to this fact and have the samples carefully washed from chlorides in case chlorides are present.

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CHEMISTRY

ENERGY COEFFICIENTS OF CRYSTALLINE LATTICES (VEC) AND THE STRUCTURE OF BINARY METALLIC ALLOYS

By O. E. ZVIAGINCEV

(Communicated by A. E. Fersman, Member of the Academy, 29.X.1942)

In recent years many investigators have attempted to find out some regularities in the formation of intermetallic phases of binary systems. The most fruitful in this field is the work by Uhm-Rothern (1). This author succeeded to make very important generalizations concerning certain groups of metals and alloys. An interesting study by Ageew (2) and some others (3) should also be mentioned in this connexion.

However, the hitherto established regularities afford no possibility in all cases to foresee the nature of the intermetallic phases of the binary alloys in the systems not investigated experimentally. We are still prisoners of pure experimentation.

This study has been planned to explore some new ways of forecasting the nature of the alloys on a theoretical basis. It has been started from the following premises:

1. The crystalline lattice of metallic alloys consists of metallic ions, the electrons torn from the atoms of the metals forming no stable pairs, chains or any other aggregates, but rather distributed in the form of a mobile electron «cloud» throughout the whole lattice of the alloy (3).

2. This cloud is formed by free electrons released by both components of a binary alloy and, therefore, the ionization potentials of the components (cations) in their common lattice should approach each other. If the ions of the components have different energy levels, no formation of the common lattice in the alloy is possible.

Hence the formation of solid solutions of intermetallic compounds will depend upon the potential levels of the ions of the components. In crystals the potential levels are for the present most completely characterized by the energy coefficients in ions (EC and VEC), according to A. E. Fersman (3).

The VECs furnish a very convenient means to compare ions of different valency.

3. Their use implies knowledge of the valency of the components. I have assumed that in the alloys a component-element of varying valency displays its highest or lowest valency, according as the temperatures of melting and transformation are high or low.

Thus, for instance, in amalgams having low melting points I have assumed the valency of mercury to be unity; in the alloys of lead and tin the valency is assumed to be 2 or 4, according as the alloys melt below or above 660° (m. p. of aluminium).

The valency of iron is put at 3, that of cobalt and nickel also at 3.

About the conduct of these elements in crystal lattices, A. E. Fersman ([3]) writes: «nickel, cobalt and manganese possess increased energy in comparison with their normal valency of 2» (p. 73). The valency of chromium is 3 and 6, of manganese 2 and 4, of gold 3; the valency of gallium is assumed to be 3, though it is possible that in the case of alloys with low melting temperature it should be put at 2. On the other hand, for bivalent gallium the VEC is not known even approximately.

4. All binary systems are divided by the author into 6 principal groups:

a) Systems with formation of an uninterrupted series of solid solutions.
b) Systems with formation of chemical solutions*.
c) Systems with limited mutual solubility of their components in the liquid state.
d) Systems with limited mutual solubility of their components in the solid state.
e) Systems with mutually insoluble components in the solid state.
f) Systems with mutually insoluble components in the liquid state.

It is obvious that the components of the systems belonging to groups «a» and «b» should, according to section 2, have their VECs nearer to each other than the components of the systems «d», «e» and «f». The systems of the group «c» have no definite position, since some of them are near to group «b» inasmuch as they have a latent maximum (dissociated chemical compound), and the others are close to the group «e».

Starting from the four premises just described, I undertook a classification of binary metallic** systems accordig to the values of VECs of their components. To begin with the systems were taken wherein one component remained constant and the other was changed. In this way a number of tables were compiled for some scores of binary systems. An example of such a table for the alloy of tungsten is given here (Table 1). A glance at this table is sufficient to notice the regular distribution of the systems into two groups: 1) systems with mutually insoluble components possessing small VECs different from VEC of tungsten, and 2) systems with the VEC of the second component above 1.65, in which case the components interact with each other.

Table 1

Tungsten Alloys (VEC—3.23)

VEC	?	0.60	?	0.82	0.87	1.05	1.05	1.10	1.65	1.71	?	?	1.80	2.12	4.01
a) Total solubility b) Chemical compound c) Limited solubility in liquid state d) Limited solubility in solid state									Al	Fe	Co	Ni	Ga	Mo	Re
e and f) Non-solubility	Hg	Ag	Sn	Pb	Cd	Mg	Cu	Zn							

Such a simple and consistent table as obtained in the case of tungsten alloys is not obtained for every other element. Thus, for instance, in the case of platinum the chemical interaction of the latter with the second component was displayed throughout the table from small to large VECs (Table 2). Platinum has no single

* The term intermetallic chemical compounds is understood here in the sense adopted by the school of N. S. Kurnakov([5]).
** Alloys between metals and non-metals etc. are not considered.

Table 2

Platinum Alloys (VEC and Pt^{+2}, Pt^{+4} and Pt^{+6} not known with certainty)

VEC	0.42	?	0.60	?	0.82	1.00	1.05	1.05	1.05	1.10	?	1.65	1.71	?	?	?	1.72	?	?	1.98	?	2.12	2.28	3.23	3.52	4.01
a) Total solubility		Tl		Hg^1		Ag		Sn^2	Pb^2	Cd		Mg	Cu	Zn	Au	Al	Fe	Co	Ni	Rh	Ir	Pd	Pb^4	Sn^4	Mo	W	Mn	Cr	Re
b) Chemical compound																	e												
c) Limited solubility in liquid state																													
d) Limited solubility in solid state																													
e and f) Non-solubility																													

valency; its valency is sometimes 2 and sometimes 4 and in the alloys also probably 6.

Consequently, the potential states of platinum may be adapted to the VEC of any metal and, according to section 2, form a chemical compound with it. Between the two extremes selected, platinum and tungsten, there are certainly intermediate cases.

Having analysed the tables for alloys with one common metal component, I proceeded to compile the general Table 3 for all metals* for which the requisite data were available on the value of VECs and the nature of the constitution diagrams. Certain metals having more than one valency are listed in the table in two places and their alloys are grouped according to their melting points in two groups.

Some qualitative conclusions follow from Table 3.

a) Intermetallic chemical compounds in binary systems are formed by metals with near VECs.

b) Complete solubility of metals in each other in the solid solution is observed in the systems formed by metals having their VECs close to each other.

c) Limited solubility and insolubility of the components of binary systems is observed chiefly in the case of metals with greatly different VECs.

d) The systems: vanadium-molybdenum, gold-cobalt, lead-cadmium, lead-tin, cadmium-tin, silver-lead, mercury-lead, cadmium-thallium and rubidium-sodium which do not follow rule «a» should be reinvestigated. Some of them have been incompletely studied. In many cases no attention has been paid to regions of low temperature**.

e) The nature of the systems yet uninvestigated may be foretold on the basis of Table 3 with a high degree of probability. Thus, for instance, in the system manganese-chromium, now investigated in the Metallurgical Laboratory of the Institute of Chemistry, Academy of Sciences of Georgian SSR, there should exist chemical interaction between the components.

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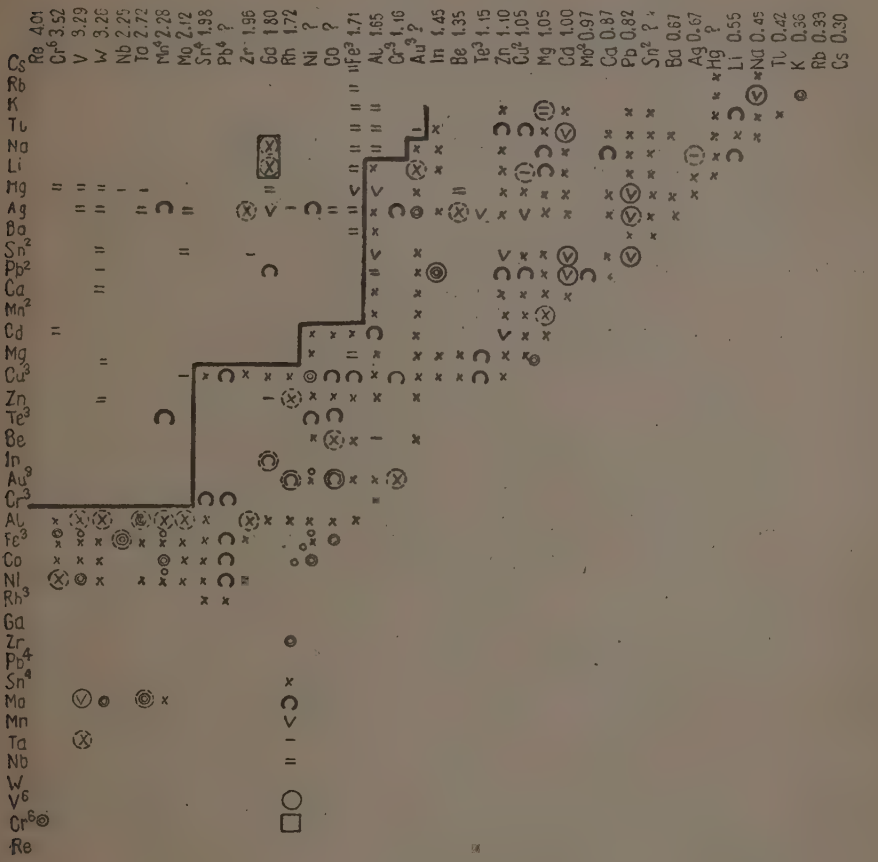
* In compiling Table 3 I used the monography of Hansen.

** In the literature there are indications regarding the possibility of existence of the chemical compounds in some of the cited systems: Pb—Sn [4], Cd—Sn [5]. As regards the systems Au—Co [6], Na—Rb [7], it should be pointed out that they have been but superficially studied.

Rhodium should combine with lead, gallium and with the metals of the iron group; with the latter the formation of an uninterrupted series of



Symbols:

- ⊙ complete solubility of the components in liquid and solid state
- × intermetallic compounds
- ⌒ limited solubility in liquid state
- V limited solubility in solid state
- — insolubility in solid state
- = insolubility in liquid and solid state
- ◌ systems insufficiently studied
- ○ systems that in our opinion require checking
- □ probably one of the components has another valency (for inst. Ga^3).

solid solutions is probable. Further foretelling of possible combinations would be superfluous. I suppose only that on the basis of the table they may be given in a great quantity.

f) Inadequate accuracy in calculating the VECs, lack of clearness in some of the determinations of the valency of metals does not permit at present to go beyond the qualitative regularity

In future I hope to approach the problem from the quantitative point of view.

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GEOCHEMISTRY

SPECTRUM ANALYSIS DATA ON GYPSUM FROM PERMIAN DEPOSITS OF TARTARY

By L. M. MIROPOLSKY and S. A. BOROVICK

(Communicated by V. G. Chlopin, Member of the Academy, 28.IX.1942)

Within the territory of the Tartar Autonomous Soviet Socialist Republic gypsum is encountered in Lower Permian and Upper Permian deposits. It occurs mainly in association with the layers of the Kungur and Kazan stages; by far more rarely with the layers of the Tartar stage; and occasionally, though very seldom indeed, is found to be associated with the Artinsk layers. In the general stratigraphic profile there is observed a gradual increase of the excretions of gypsum among Lower Permian deposits and the upper portion of the Kungurian beds, and among Upper Permian deposits to the upper portion of the Kazanian formations. The separation of gypsum is extinguished and comes to an end somewhere in the middle portion of the Tartar stage.

Between the gypsum occurring in the Permian deposits the following discrimination can be made with reference to origin: 1) the primary gypsum which is a right-away chemogenic deposit; 2) the secondary gypsum formed by the hydration of anhydrite, and 3) the secondary gypsum that separated from migratory solutions along fissures and in cavities (selenite, Mary glass, isolated crystals) ([1], [2]).

The purpose of these spectrum investigations of gypsum has been, first, to estimate with precision its chemical composition in the different stratigraphic horizons of the Permian on samples taken from the most thoroughly explored deposits; secondly, to establish the distribution of chemical elements in its different generations; and thirdly, to trace the influence which variations in the composition of gypsum may have had upon some of its typical morphological features.

There were 17 specimens of gypsum subjected to a qualitative spectral analysis: two from the region of the vil. Pechishchi, five from Krasnovidovo, three from Kamskoe Ustie, five from Suykeevo and two from Kamskie Poliany. Of them three were primary gypsum; ten belonged to secondary gypsum arisen from the hydration of anhydrite; the remaining four were secondary gypsum formed by crystallization from solution in cavities. This was indeed a fairly representative set of samples because of differences in origin and in structural and morphological characteristics.

The technique of taking the spectrograms was as follows. The material was burnt in an electric arc flame (a. c., 220 volt, 10 amp.); the spectra of this flame were photographed with a Q-24 quartz spectrograph of Zeiss. Two spectrograms were taken in succession from every specimen; the second of them gave an intensified representation of the lines of not easily volatile elements and of the ionized atom lines. Analysis was made for 55 elements: Li, Be, B, Na, Mg, Al, Si, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Sr, Y, Zr, Nb, Mo, Ag,

Cd, In, Sn, Sb, Te, Ba, La, Ce, Pr, Nd, Il, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tu, Cp, W, Os, Ir, Pt, Tl, Pb and Bi. Of them only 15 were found to be present in gypsum: Li, Be, B, Mg, Al, Si. Ca, Ti, Mn, Fe, Cu, Sr, Y, Zr and Bi.

The results obtained after deciphering the spectrograms are referred to in the adjoined table.

No.	Locality and main characteristics of the samples	Age of deposit	Elementary composition													
			Li	Be	B	Mg	Al	Si	Cd	Ti	Mn	Fe	Cu	Sr	Y	Zr	Bi
	I. Primary Gypsum																
1	Vil. Krasnovidovo, right bank of Volga, mt. Krasnyi Myss, from layer «Opoka». Fine-grained, yellow-brown	$P_2^{kaz_2}$	4	—	2	2	—	3	A	C	3	b	5	b	—	2	—
2	Vil. Kamskie Poliany, left bank of Kama, well No. 101, sample No. 92, depth 130. 91m. Fine-grained, white	P_1^k	—	—	—	2	4	1	A	b	—	1	3	a	—	4	—
3	Ditto, well No. 101, sample No. 134, depth 179. 10 m. Fine-grained, white	P_1^A	—	4	—	3	4	1	A	b	—	2	4	1	—	—	—
	II. Secondary Gypsum (by way of hydration from anhydrite)																
4	Vil. Pechishchi, right bank of Volga, from layer «Podluzhnik». Spar-like, velvet-black	$P_2^{kaz_2}$	—	—	—	3	—	3	A	b	4	b	5	1	—	2	—
5	Ditto, from layer «Shikhany». Aciculate, white	»	—	—	3	b	2	b	A	b	3	b	5	1	2	—	—
6	Vil. Krasnovidovo, mt. Krasnyi Myss, from layer «Golovka». Fine-grained, white	P_2^{tat}	—	4	2	a	b	C	A	b	b	C	2	b	—	—	—
7	Ditto, from layer «Sloy». Fine-grained, pinkish-red	»	—	—	3	a	3	b	A	b	3	b	5	a	—	—	—
8	Ditto, from layer «Seryi kamen». Fine-grained, white	$P_2^{kaz_2}$	—	—	3	a	b	C	A	b	3	b	—	C	2	—	—
9	Vil. Kamskoe Ustie, right bank of Volga, near the factory «Deviatoe Janvaria», from layer «Podluzhnik». Spar-like, smoke-coloured	»	—	—	—	2	4	1	A	b	—	1	4	b	—	4	—
10	Ditto, from layer »Semiarshinyi». Aciculate, greyish-white	»	—	—	3	b	b	C	A	b	3	a	5	1	3	—	—
11	Ditto, from layer «Semisazhenyi». Aciculate, white	»	—	—	3	b	2	b	A	2	4	a	5	1	—	—	—

Continued

No.	Locality and main characteristics of the samples	Age of deposit	Elementary composition														
			Li	Be	B	Mg	Al	Si	Cd	Ti	Mn	Fe	Cu	Sr	Y	Zr	Bi
12	Vil. Suykeevo, right bank of Volga, from layer «Seraya Perekhodnaya tolshcha». Recrystallized, white	$P_2^{kaz_2}$	—	—	—	2	—	3	A	2	2	1	4	1	—	4	—
13	Ditto. Spar-like, green .	»	—	—	3	B	2	a	A	a	b	b	4	1	—	3	—
	III. Secondary Gypsum (separated from migratory solutions in cavities)																
14	Vil. Krasnovidovo, mt. Krasnyi Myss, from lower portion of the Tartar stage. Selenite, pinkish-red	P_2^{tat}	—	—	—	b	1	b	A	1	C	b	3	1	—	—	—
15	Vil. Suykeevo, near ravine «Rucheek» from layer «Seraya perekhodnaya tolshcha». Selenite, white with a barely distinct pinkish shade	$P_2^{kaz_2}$	—	—	—	b	4	b	A	4	3	b	—	1	—	—	—
16	Ditto, from layer «Podluzhnik». Mary glass, perfectly transparent and colourless	»	—	—	—	1	1	2	A	3	—	1	—	1	—	—	—
17	Ditto, near ravine «Syukeevsky vzvoz», from layer «Seraya perekhodnaya tolshcha». Transparent and colourless crystals	»	—	—	—	a	3	b	A	b	1	b	4	1	—	—	2

Symbols for Intensity of Lines on Spectrograms

A — extremely strong	1 — weak
B — very strong	2 — very weak
C — strong	3 — traces
a — above medium	4 — insignificant traces
b — medium	5 — barely visible

The conclusions to be drawn from this table are as follows:

1) All of the investigated samples of gypsum have a rather simple chemical composition; they contain only few accessory elements, most of which are in quite insignificant concentration.

2) There are no striking differences in the composition of samples taken from different stratigraphic horizons. Their elementary composition is essentially similar. Only the gypsums containing Li, Be, B, Cu, Zr, Y and Bi deserve special attention.

3) Ca is always the leading element. Next in importance are Mg, Si, Ti and Fe. In some cases Al, Mn and Sr play a significant part. Li, Be, B, Cu, Y, Zr and Bi occur only as traces.

4) The content of Mg, Al, Si, Ti, Mn, Fe and Sr, as reflected in the intensity of the respective lines, shows considerable fluctuations.

5) On the other hand, never any but scarcely appreciable deviations are observed in the content of B, Cu and Zr, judging by the intensity of their lines.

6) Three groups of elements can be distinguished from the rest in view of their wider occurrence: 1) Mg, Si, Ca, Ti, Fe and Sr are always present; 2) Bi, Al, Mn and Cu are met with frequently; 3) Li, Be, Y, Zr and Bi occur sporadically. Comparing the chemical composition in different specimens with reference to their genetic type, it appears that the secondary gypsum that seems to have been separated from infiltrable solutions in a spontaneous way has a more simple composition.

From the constant occurrence of Si, Fe, Sr anl partly of Mg and Al it may, perhaps, be inferred that certain quantities of these elements play the rôle of mechanical admixtures in the form of quartz, chalcedony, opal, goethite, hydrogoethite, celestine and fine-silt components. Most of the elements, however, enter into the lattice of gypsum as isomorphous admixtures, according to the principle of compensating and polar isomorphism.

At the same time the results of these spectral analyses lead to the conclusion that among all of the observed admixtures the most interesting in point of colour are Fe, Ti and Cu. In terms of their quantities can apparently be explained both the intensity of colour characterizing a given specimen of gypsum and the variety of shades observed.

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MINERALOGY

A MONCHIKITE FROM TAKOB (TADJIK SOVIET SOCIALIST REPUBLIC)

By S. D. CHETVERIKOV

(Communicated by A. E. Fersman, Member of the Academy, 12.VII.1942)

In 1940 a dike of black lamprophyric rock was discovered by eng. Mochkin near a new building site in the region of the Takob fluorite deposit. The dike (strike, 270°; dip, S.-W., 50°) lies in a biotite granite on the left bank of the riv. Varzob-balo at the confluence of the rivers Diamalik and Takob. Its thickness varies from 1.5 to 0.2 m. It is crossed and faulted by a quartz vein. Dikes similar in appearance have also been disclosed on the road from Varzob to Takob.

Macroscopically the rock described is a greenish-black mass containing fine needle-like crystals of amphibole and the more isometric crystals of pyroxene. Here and there small pores are to be seen. Under the microscope the rock shows a porphyritic structure with a vitrified groundmass.

Phenocrysts are represented by idiomorphic crystals of monoclinic pyroxene from titan-augite series and by fine prismatic barkevikite. Rarely pseudomorphs of serpentine are encountered amidst idiomorphic crystals of olivine. The groundmass of the rock is largely a brownish mass of no uniform colour throughout, with large quantities of fine needle-like crystals. Sometimes the needles form transitions to the fine prismatic crystals of amphibole. Among these needle-like formations one may surmise the presence of apatite. Ore minerals are represented by small grains of magnetite.

In the glass granules of calcite are dispersed.

No definite orientation of crystals is observed in the texture of the rock, save that around the occasional pores one may note their streamlining by the amphibole needles. Pyroxene should have separated somewhat earlier, since its crystals cut into the prisms of barkevikite. The former makes up about half the mass of the rock and belongs to the monoclinic series. Its composition shows strong variation even within the limits of a single crystal. In some crystals their middle part is a greyish-green colour, though without a visible pleochroism. There is a coloured nucleus in others, and such crystals are nearly colourless with a greyish-lilac tinge and a feeble pleochroism only in their peripheral portion. The crystals of pyroxene are often twinned with respect to 100 or according to more complicated laws, and, occasionally, grown together into crosses or bundles. Cross-sections often show a predominance of the prism (110) over pinacoids (100) and (010).

Birefringence is near to 0.025, and on sections cut parallel to the plane of optical axes a wasp-waisted structure is sometimes distinctly visible. In other sections a zonal extinction with strong dispersion of bisectors is expressed very sharply. The extinction angle varies from 39° n_g in the colourless portion

(diopside) to 45° in the coloured peripheral portion (titan-augite). Numerous measurements of the angle formed by optical axes, carried out for two axes in both blue and red monochromatic light, showed certain deviations in the value of $2V$ for the nucleus and the peripheral part of the crystal.

Value of $2V$

	Blue light	Red light
Nucleus	56°	58°
Periphery	54°	57°

The measurements were made with Melancholine plate and Leitz segments. $n = 1.648$, without allowing for the difference in the refraction indices and the dispersive power of the segment's glass.

From their properties, as just described, these pyroxene crystals can be referred to the titan-augite series. The amphibole forms fine prismatic crystals which are frequently needle-like and nearly always twins with respect to some of the prism faces. Birefringence near to 0.020—0.021. Angle of extinction n_g: $c = 13°$. The size of the crystals being too small, it was not possible to determine the magnitude of $2V$ with respect to two axes (the measurements were made with the 1M4 lens). From three determinations with respect to one axis there was obtained an average of $2V = 82° \pm 2°$. Typical are the colouring and the pleochroism of the investigated amphibole: n_g, greenish-brown; n_m, reddish and greenish-brown; n_p, brownish-yellow. The peripheral part of the crystal is a clearly expressed bluish-green superposed upon a red-brown. By analogy to titan-mullites from mullite refractories the bluish-green colour is attributable to the presence of considerable quantities of titanium oxides in the peripheral part of the crystal. From its properties the amphibole studied should be referred to the barkevikite series.

The chemical analysis of the rock by I. Tuchin gave the following results (Table 1).

Table 1

	Per. cent	Amphibole from monchikite Kopingney (Orkney islands)	Augite from monchikite Sierra Tingua (Brazil)
SiO_2	41.84	40.65	44.55
TiO_2	1.83	4.52	2.85
Al_2O_3	14.55	17.12	7.86
Fe_2O_3	3.24	4.26	3.81
Cr_2O_3	0.06	—	—
FeO	7.42	5.53	4.53
MnO	0.25	0.34	0.38
MgO	3.36	9.96	12.71
CaO	13.76	12.88	20.84
Na_2O	2.63	1.74	1.29
K_2O	1.62	2.80	0.49
P_2O_5	0.38	—	—
V_2O_5	0.03	—	—
Loss on ignition*	3.84	H_2O^+ 0.36	—
H_2O	0.42	—	—
Total.	99.23	100.16	99.31

* Mainly CO_2.

The analysis of monchikite (1) recalculated in terms of Niggli indices gives (Table 2):

Table 2

	I.	II		I	II
Si	91	90	mg	0.6	0.25
al	18	20	c/fm	0,76	0.8
fm	42	40	t	—22	—20
c	32	32	qz	—41	—42
alk	8	8	t	3	—
K	0.3	0.25	p	0.3	—

Under II are listed the indices for the berondrite type of gabbro theralite magma of the natron series (according to Niggli). To that type of magma can be referred the rock investigated, as is obvious from comparing the data of the first and the second column. From the negative quartz number the rock appears to be greatly undersaturated with silica, and recalculation for mineralogical composition according to Niggli yields several variants.

	Cc	Cp	Kp	Ne	Cal	Cs	Fs	Fa	Fo	Ru	Q
Basic composition	5.0	0.6	5.9	15	14.4	6.1	3.5	9.0	16.4	1.3	2.28

	Cc	Cp	Or	Ne	Ab	Au	Wo	Mt	Fa	Fo	Ru	Accessory
Cata-norm:	5.0	0.6	9.8	1.5	22.5	24.0	8.1	3.5	7.25	16,4	1.3	10.4

Salic 57.5
Femic 31.8

The light-coloured portion is almost entirely represented by feldspars; the dark-coloured, by olivine.

	Cc	Cp	Or	Ab	Ne	Ts	Wo	Mt	Hy	En	Ru	Accessory
Metasilicate variant	5.0	0.6	9.9	18	4.2	17.9	8.1	3.5	9.6	21.9	1.3	10.4

Salic 32.1
Femic 57.5

If the composition of the rock is to be represented graphically in terms of quantitative mineralogical composition, one may project it into a triangle *QLM* (Fig. 1).

Here can also be marked out the points corresponding to the analysis of titan-augite and barkevikite referred to above:

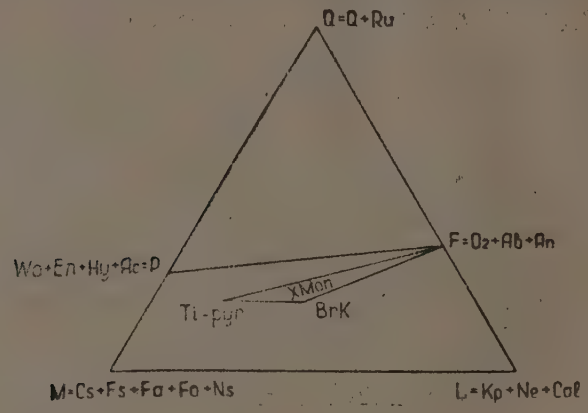
	Kp	Ne	Cal	Cs	Fs	Fa	Fo	Ru	Q	
Titan-augite	1.7	7.1	8.5	27	4	5.2	27	2	17.5	
Barkevikite	10.0	9.3	18.3	10	4.5	6.4	21.2	3	17	(1 w)

For projecting into the triangle *QML* we have:

	Q	*M*	*L*
Titan-augite	19.5	63.2	17.3
Barkevikite	20	42.1	37.6
Monchikite	25	37	38

The point (mon) for monchikite fits into elementary triangle Ti-pyr-Brk-F (Fig. 1), and the quantitative proportion of the components is Ti-pyr, 20%; Brk, 58%; F (glass), 22%; calcite and apatite are neglected. The light-coloured portion is of feldspar rather than feldspathoid character, and all the excessive alkalinity must be attributed to the dark-coloured portion.

Selective calculation for three thin-sections with a micrometer and a 1200-division slide-rule made in the laboratory of B. M. Kupletsky gave the following results in per cent by volume: augite, 28.8%; barkevikite, 23.7%; chlorite, 3.2%; zeolite + calcite, 1.7%; ore, 0.1%; glass, 42.5%. Discarding the admixtures of minor importance, we have 30% of augite, 25% of barkevikite, 45% of glass.



In Table 3 data obtained in different ways are brought together (in %).

Table 3

	Augite	Barkevikite	Glass
Per cent by volume, according to visual counting	30	25	45
From triangle plot according to molecular normative counts, minus accessories	20	58	22
	64		36*
Berondrite (Lacroix)	18	47	34*
Mafraite (Lacroix)	11	47	42*

* By glass is here meant the total of salic minerals.

The reason for the strong divergence between the figures of the first and the second count may first lie in the difference between volume and weight per cent and then in a significant inaccuracy of the visual counting of very fine aggregate needles mixed with glass in the rock investigated. Titan-augite and barkevikite were assigned the composition which these minerals are known to have in other deposits, though it is actually not constant.

Conclusions

In the Takob deposit a vein of monchikite has been discovered amidst a biotite granite, which is quite an unusual occurrence. The fact leads one to surmise the existence of very complicated petrographic relations in this region and calls for a more thorough investigation of this practically important deposit.

Niggli's method of normative molecular counts can in this case be used to advantage for estimating quantitatively the proportion of mineral phases on the basis of the gross composition of the rock, and the calculation is greatly facilitated by graphical representation.

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PLANT PHYSIOLOGY

CONTENT OF VITAMIN C IN CULTIVATED AND WILD PLANTS GROWING IN HIGH REGIONS OF PAMIR

By V. D. KOSTENKO

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The unfavourable conditions of climate to which plants growing in elevated, mountainous, localities are subject, tend to modify their biochemical processes with the result that a higher physiological resistance is acquired. In the first place there is observed in them an increased accumulation of physiologically active substances, such as enzymes and vitamins.

Table 1

Content of Vitamin C in the Plants of East Pamir

Name of plant		Vitamin C, mg %
Cultivated		
Radish	«Letnyi belyi shar» (Summer white ball)	26
	Saxa, mixture	30
	Hot-bed variety, Moscow	23
	Dragotsennost («Jewel»)	32
	Saxa	28
	Red-and-white	35
	Icicle	35
	Pink with white tip	38
	Würzburg	32
	Sparkler	36
	Crimson ball	19
	Crimson giant	28
	Meteor Cooper Tiber	24
	Pinkish red with white tip	30
	Graivoronskaya	24
Turnip	Petrovskaya	30
Beet	Egyptian	7
Carrot	Nant	14
	Shantane	12
Onion	Ailso Crug Carter	62
Spinach	Gaudfay	175
	Queen of Holland	105
	Matador	98
Cabbage		142
	chinese No. 110771	167
	» No. 173	147
	» No. 121819	98
	» Shandun	84
Cultivated		
Lettuce Wonderful		74
	Ves God (All the year round)	78
	Moscow, Hot-bed variety No. 969	55
Sorrel		108
Barley *pallidum* 04 original		143
	second reproduction	148
	nigricans 010894	136
	Archangel *coeleste*	205
Triticum vulgare erythrospermum		115
	» Northerner	290
Triticum durum (Mediterranean)		170
Couch-grass American		208
Wild Plants		
Eurotia ceratoides (specimen of delayed growth and development)		228
Eurotia ceratoides (strong growth)		193
Zygophyllum obliquum		133
Atriplex pamirica		129
» *centralasiatica*		129
Gypsophila pamirica		0
Clipolymus nutans		159
Stipa gloreosa		191
Rheum spiciforme		110
Aneurolepidium dasystachys (delayed growth)		166
Aneurolepidium dasystachys (intensive growth)		153
Somarum Salessowii		522
Artemisia pamirica		189

For three years the author has been engaged in studying the accumulation of ascorbic acid in plants, and his observations go to confirm the data reported earlier by V. Blagoveshchensky and E. Grebinsky to the effect that plants increase their content of vitamin C in response to the climatic conditions prevailing at high altitudes.

An increase of content of vitamin C has been established, for instance, in the garden crops grown at 3860 m above the sea level in the valley of Ak-Baital, East Pamir. In those of them which are cultivated for their leaves the difference is especially high (two or three times). To this class belong different varieties of spinach, lettuce and cabbage.

The fact that vegetables increase in vitamin C when grown in high regions is certainly a good argument for organizing their cultivation there on a large scale.

Also wild plants of East Pamir are distinguished by their high content of ascorbic acid. Some of them are of interest as raw material for the manufacture of concentrates. The greatest quantities of vitamin C have been detected in the leaves of *Somarum Salessowii* and *Eurotia ceratoides*.

In West Pamir, too, a reconnaissance survey of wild plants with regard to their vitamin content was carried out on the initiative of the Pamir Botanical Gardens. It was found (Table 2) that among wild roses there are forms very rich in vitamin (up to 4.02%). Now the wild rose is a very common plant in the valleys of West Pamir and is spread there over wide areas. So the mass collection of its fruit in these localities seems to be a very promising undertaking.

Table 2

Name of plant	Vitamin C, mg %	Name of plant	Vitamin C, mg %
Cultivated		Wild Plants (fruit)	
Raspberry	26	Mountain ash, late	35
Tomato (Budenovka)	20	» » early	32
Mulberry (dried fruit)	21	*Rosa biglantheria*	2065
Potato (tubers)		*Rosa beggeriana*	3250
Centifolia	37	*Rosa* sp. (fruit with thorns)	2130
Edelgard (resistant to cancer)	25	» » (elongated, without thorns)	4020
Solanum curtilobum	13	» » (smooth shape)	3290
» *phareja*	27	*Cotoneaster racemiflora*	53
» *commersonii* (Uruguay)	24	*Ribes Meyeri*	32
» *Yamesii*	32	*Hippophaë rhamnoides*	105

It will be obvious that in high regions both the native and the introduced plants are unusually rich in ascorbic acid.

The content of ascorbic acid increases with the altitude, and so we find it to be connected with the changes in the rhythm and rate of photosynthesis.

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ECOLOGY

PARALLELISMS IN THE FORMATION OF ENTOMOCOENOSES OF GRAIN FIELDS IN EASTERN EUROPE AND NORTH AMERICA

By M. S. GHILAROV

(Communicated by I. I. Schmalhausen, Member of the Academy, 16.VII.1942)

One of the fundamental conceptions of modern ecology is that of «biocoenosis», by which is understood an interdependent association of organisms, living under given conditions(1). On a scale of vast territories (say, of a continent) the complex of animals inhabiting the latter is definitely related to the fauna of the locality.

The various organisms of the biocoenosis have a definite «functional significance»(2), occupying, to adopt Elton's expression(3), definite «niches» and being interrelated with the rest of the components of the biocoenosis.

The conception of «vicarious species», i. e. similar species in different zoogeographical provinces or districts, has long been established in zoogeography; the term is usually applied to cases of resemblance due to convergence or parallel evolution. From the viewpoint of ecology, vicarious species are such as occupy similar «niches» in similar biocoenoses.

It would be of interest to make clear whether in different zoogeographical regions showing similar climatic conditions there takes place formation of analogous biocoenoses. This question can be solved experimentally. If similar changes in the environment are followed by analogous variations in the number of convergent or parallel species, there is reason to speak of a similarity of the biocoenoses, of an ecological equivalence of their components. In other words, the identity of biocoenoses may be evaluated from the character of the formation of secondary biocoenoses. Such changes are brought about by the agricultural activity of man.

If some crop shows the formation of similar secondary biocoenoses when introduced into culture in different localities, this points to the identity of the initial biocoenoses and to the equivalence of their components. When a plant is introduced into culture, favourable conditions are created for the propagation of those species which are able to feed upon it (especially mono- and oligophagous species directly depending on certain food-plants).

As a criterion of the numerical growth of a species of plantivorous insects may be used the economically significant damage caused by it, the record of a given insect as a crop pest of economic importance.

The article contains a short survey of the phytophagous complex of secondary, entomocoenoses of Eastern Europe and North America. As cereals, in particular wheat, have long been cultivated both in the Palaearctic and Nearctic region, occupying there considerable areas, the entomoceonoses of these crops are ecological units of a rather high stability if compared to the rest of secondary entomocoenoses.

In North America it is possible to distinguish climatic zones similar to those of East Europe. Now is there any resemblance between the complexes of insect pests attacking the cereals in the European part of this country and in North America?.

Among the insect pests affecting grain crops, causing losses of economic importance, there are but a few species common to both continents. These are the Hessian fly (*Mayetiola destructor* Say.) and the grain-aphis (*Toxoptera graminum* Rond.); both species are of European origin and have but recently been imported in North America([4]). Besides these, the entomocoenoses of grain fields have been formed of representatives of indigenous autochthonous stations.

The root-system of cereals, especially in the young plants when they have appeared above ground, is subject in both continents to attacks by the wireworm. In Europe, within the zone of high humidity, the most dangerous representatives of this group are *Agriotes lineatus* L. and *A. obscurus* L.; in North America (New England), in districts offering similar climatic conditions, analogous losses are caused by the «wheat-wireworm», *Agriotes mancus* Say.([5]).

In more arid Western States of America the roots of cereals are damaged mostly by representatives of various species of *Ludius*([6,7]): the larvae of these beetles approach, both morphologically and ecologically, those of *Selatosomus latus* F., which are the most pernicious soil pests all over the eastern provinces of the European part of the USSR.

In the steppe zone of this country germinating cereals are damaged by larvae of *Blaps* (*B. lethifera* Fisch., and *B. halophila* Marsch), while under similar conditions in America (to the west of the Mississippi) damage is caused by larvae of other *Tenebrionidae* beetles, viz., by *Eleodes* (*E. opaca* Say., *E. suturalis* Say.), which greatly resemble the *Blaps* as to their general habitus, duration of life-cycle and behaviour (typical attitudes).

In Eastern Europe the roots of cereal are damaged by larvae of the june-beetle (*Amphimallon solstitiale* L.), the pest affecting especially newly plowed uncultivated soils. In the Nearctis under similar conditions damage is caused by similar larvae of the American june-beetle, gen. *Phyllophaga*.

In the USSR important damage is caused to grain crops by the cutworms (the «winter-sowing» cutworm *Euxoa segetum* Schiff.) and a number of allied species, which cut off the underground parts of the plant near the soil surface. Instead of these pests we find in North America quite a different complex of *Noctuidae* species; among these the most pernicious and most widely distributed is the «pale western cutworm», *Porosagrotis orthogonia* Morr.

Cereals sown on freshly plowed sod-land are liable to be cut off at the surface of the soil by larvae of the sod-webworm (*Crambus*) which inhabit in their loose silken web the underground parts of the plant. In Europe such a damage is caused by *Crambus jucundellus* H. S. and *C. luteolellus* Schiff., in America by *C. luteolellus* Clem. and *C. mutabilis* Clem.

Of indigenous *Diptera* stems of wheat in North America are invaded by larvae of *Meromyza americana* Fitch.; in Europe the corresponding pest is *M. saltatrix* L.

The presence of *Hymenopterous* larvae, feeding and developing within the stems of wheat, cause the appearance of charasteristic swellings; in America such swellings are due to the harmful activity of larvae of *H. grande* Ril., *H. tritici* Fitch. In the USSR analogous injuries are caused by *H. rossicum* R. Kors., *H. noxiale* Portsch. and others. In the European part of this country hollows at the base of the stem in cereals are inhabited by larvae of the sawflies, *Cephus pygmaeus* L. and *Trachelus tabidus* F., which previous to pupation cut off the stalk and plug the stub with sawdust.

Analogous injury is caused in North America by larvae of the wheatstalk sawfly, *Cephus cinctus* Say.

In Europe the heads of wheat serve as a shelter for larvae of the wheat-midge, *Contarinia tritici* Kby. In America the vicarious species corresponding to it is a representative of another genus of *Coecidomyidae*, *Thecodiplosis mosellana* Gehin.

Severe damage is inflicted upon wheat in the steppe zone of the European part of the USSR by *Pentatomidae* bugs of the genus *Eurygaster*, which suck the sap out of various parts of plant. In North America the analogous «niche» is occupied by the «chinch bug», *Blissus leucopterus* Say. (*Lygaeidae*).

The European «stem-cutworms» (*Oria musculosa* Hb., *Trachea secalis* L.) are to a certain extent vicarious for the American «army-worms» (*Cirphis unipunctata* Haw., *Neleucania albilinea* Hübn., etc.).

Among the species injurious to grain crops in Europe there are but a few that have no analogues from the ecological point of view in North America. To such seem belong *Zabrus* spp., *Lema melanopus* L., and some others. But, generally speaking, the associations of insect pests affecting ‚cereals' (in particular, wheat) are made up on both continents largely of ecologically similar components, causing analogous injuries, and alike with respect to their biophenology.

Thus, the cultivation of homogeneous grain crops over vast areas in East Europe and North America has led to a formation of identical secondary entomocoenoses, i. e. to analogous changes in natural communities. It may therefore be supposed that primarily the biocoenoses of Palaearctis and Nearctis had been identical and that, under the influence of similar changes in the environment, not only single species, but entire biocoenoses as well, have undergone parallel or convergent variation.

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EXPERIMENTAL MORPHOLOGY

MORPHOGENESIS IN AXOLOTL UNDER THE INFLUENCE OF THE DERIVATIVES OF HYDROLYZED CARTILAGE

By D. M. FEDOTOV

(Communicated by I. I. Schmalhausen, Member of the Academy, 22.IX.1942)

The problem of organizers as formulated by Nassonov in his studies of the adult animals(1) is of importance both from theoretical and practical point of view. Investigations of this author have shown the presence in animal tissues of organizing substances responsible for the development of additional structures and malformations. Further working out of this problem in various directions is now being continued in this laboratory(2). The common investigation by Fedotov, Silaev and Kosheleva is devoted to the problem of the optimal conditions of tissue hydrolysis and of the morphogenetic effect of the products of hydrolysis on axolotls.

At present nobody denies the rôle of chemical substances in morphogenetic processes, although there is no concord of opinions as to the nature and the mechanism of their action. This disagreement is due to two causes: first, the use for the experiments of embryos, and, secondly, the great difficulties that are connected with the study of developing organism. The complexity of the problem in question is clearly seen in the paper by Finkelstein(3). The chemical properties of the substances are far from being thoroughly enough investigated, but the specific action of these substances capable to induce the different systems in amphibian embryos is usually denied. On the other hand, in a number of recent investigations, in which there was applied material other than embryos, the opposite opinion is upheld. For example, Rapoport has shown(4) on *Drosophila* larvae the specific effect of a number of chemicals which are toxic for ferments and give rise to morphoses. In full agreement with Rapoport, we were able to induce malformations treating not the embryos, but free-living organisms having completely differentiated tissues and organs, a large part of which is normally functioning. The regulative possibilities of such an organism are limited and more strictly determined as compared with the embryos. This is why the treatment of the problem on adult animals observed at a suitable stage gives a more definite answer as to the nature of the chemical substances capable to induce the development of tissues and organs.

Silaev carried out a number of experiments on the hydrolysis of tissues and of organs, including the cartilages. Acid as well as alkaline (1% NaOH) hydrolysates of different duration and different degrees of composition were tested on axolotls (Fedotov and Kosheleva). After many unsuccessful attempts we succeeded in obtaining such hydrolysates of the cartilage that showed a morphogenetic effect in hundred per cent of cases.

Such proved to be the hydrolysate of cartilage in 25% formic acid obtained by Silaev in the chemical laboratory of the Moscow State University. The

hydrolysis lasted 21 months and 13 days and the hydrolysate obtained showed a feeble biuretic reaction, and its ratio characterizing the disintegration of tissues NH_2/N was equal to 48.55%. The filtrated hydrolysate, very small in amount, was evaporated in vacuo at room temperature until the acid was completely removed. Clots of the jelly hydrolysate, about 0.3 mg, were placed to 11 axolotls, three-month-old, under the skin of each leg (44 insertions altogether). After some days the hydrolysate insertions caused strong inflammatory processes: large tumours and blisters, inflammation of the blood vessels, abundant haemorrhage in the legs at the points of insertion. Approximately by the end of the second week after the operation the inflammation gradually decreased, the tumours disappeared, but there still remained small solid tubercles. The latter gradually increasing in size, by the end of the first month these tubercles developed into leg rudiments, with rudiments of digits. After 1.5 months all the experimental animals had on their two, and more often on three legs, additional 4-digitate and 5-digitate small legs on their fore and hind original legs, respectively. Three months later, when the experiments were interrupted, these new-formed legs but little lagged behind the original legs in development (Figs. 1, 2). In a number of cases the latter were bent backward, their palm side being directed upward and outward, so that the new developed leg replaced the old one, and the animal could move with the help of its new legs (Fig. 2, *A*). In a number of experimental animals (Figs. 1, 2, *C*) there developed two or even three additional legs with or without the full number of digits. To these malformations Nassonov gave the name of superadditions(1). It should be noted that in four cases at the place of original tarsus there were formed superregenerates; either legs with supernumerary digits or two tarsus with an insufficient number of digits. As a result of 44 insertions, there were formed no less than 31 superadditions and 4 superregenerates. The results described go to confirm Nassonov's point of view as to the organizing rôle of chemical substances due to tissue disintegration.

Fig. 1. An axolotl with additional legs developed under the influence of subcutaneously inserted cartilage hydrolysate in 25% formic acid. On the left fore leg there developed one 4-digitate leg; on the right hind leg, two 5-digitate legs; on the left hind leg, one 5-digitate leg and one digit. The right fore tarsus has dropped off and a 4-digitate leg and two additional digits regenerated at its place. Slight magnification.

Similar results as to the development of additional organs were obtained in experiments with axolotls of the same age treated in the same way with cartilage hydrolysate of axolotl in 1% HCl. Hydrolysis in the case of this hydrolysate lasted 3 years, 7 months and 21 days. After having removed the insoluble residue consisting of connective tissue elements, the hydrolysate was repeatedly evaporated in vacuo completely to remove HCl, then it was neutralized with 0.2 *N* NaOH and evaporated to jelly condition. According to Silaev's data, this hydrolysate showed a somewhat lower degree of tissue decomposition, its NH_2/N ratio being equal to 33.69%, i. e. 14.86% less than in the preceding case. The whole nitrogen (after Kjeldahl) and amino-nitrogen (after Sërensen) content, as determined by Silaev, was equal to 11.25 and 3.79 mg, respectively. The hydrolysate showed a positive biuretic reaction, i. e. it contained a mixture of polypeptids, beginning with tripsides.

This hydrolysate was introduced under the skin of all 4 legs of 3-month-old axolotls. Two animals from this lot were characterized by one additional leg with 5 digits, while the third animal had an additional leg with 6 digits. The

introduction of the same hydrolysate to 2-year-old axolotls gave no malformations, although it was followed by a very strong inflammation and destruction of the skin.

The morphogenetic effect of the hydrolysates should, probably, be explained by the difference in degree of tissue disintegration pointed out above. Kuzmina has recently shown[5] that the development of additional legs under the influence of disintegrating muscles depends, in a high degree, upon the age of the experimental animals. It is possible that this was the cause of the failure of our treatment with 1% HCl hydrolysate of 2-year-old axolotls.

We have carried out control experiments which showed that the positive results with acid hydrolysates were no accidental ones. 37 insertions were simultaneously performed with other hydrolysates and all these gave no morphogenetic effect, except a strong inflammation. Among the latter were: 10 axolotls that received the cartilage hydrolysate in ice acetic acid (hydrolysis lasted 4 months); 15 axolotls were treated with a cartilage hydrolysate in 1% NaOH (hydrolysis during 2 months and 13 days); 12 axolotls were treated in the same way with cartilage hydrolysate in 1% NaOH (hydrolyzing period was equal to 3 years, 1 month and 12 days). According to Silaev, the NH_2/N ratio in the last hydrolysate was 35.34%.

Fig. 2. *A*, right fore extremity, old leg bent backward, a some smaller new one bent forward. *B*, right fore extremity, on whose elbow a new leg bent forward has developed. *C*, left fore extremity; old leg bent backward; two new additional 4-digitate legs that have formed upon it look sidewise. Slight magnification. Figs. 1 and 2 are taken from the same series of experiments.

It showed a feeble biuretic reaction. The hydrolysate was neutralized with 0.2 *N* HCl and applied as a jelly. Silaev believes that prolonged action of alkali on the hydrolyzing tissues and on their products completely destroys the form-building substances or changes their nature essentially, which prevents morphogenesis in the case such hydrolysate is applied.

The per cent of additional structures in our experiments was much higher than that in similar experiments by Nassonov and Silaev[1,6]. It is true that they used older axolotls than we did. According to the review of Nassonov's experiments made by A. Peredelsky[7], in series No. 66 (14 axolotls, 129 insertions of alkaline cartilage hydrolysate) there were obtained two 3-digitate malformations; in series No. 67 (14 axolotls, 140 insertions) one 3-digitate malformation was obtained. The remaining malformations in these experiments were represented mainly by tubercular outgrowths and partly by digit-like malformations. In other words, most of them belonged, according to Nassonov's terminology, to the type of primitive malformations. It is evident that the conditions of hydrolysis of the cartilage in 25% formic and in 1% chloric acids are more favourable for the investigation of morphogenetic reactions proceeding under the influence of chemical products of tissue decomposition than conditions of alkaline solutions.

Quite recently we were able to obtain malformations under the influence of enzymic hydrolysates of the cartilage (catepsin and tripsin hydrolysates; duration of hydrolysis from 45 hours to 10 days). They were prepared by Sokolova by acting on the cartilage with crystalline catepsin during 70 hours at 37° C (citric buffer and cystein as activator). Six axolotls were treated with this hydroly-

sate and all of them were found to develop from 1 to 4 malformations having 1 and 2 (very rarely three) digits.

Similar additional rudiments developed under the influence of other enzymic hydrolysates, although in the smaller per cent of animals. Thus, the morphogenetic effect of enzymic hydrolysates was found to be much weaker than that of the prolonged acid hydrolysates. It may be suggested, however, that the optimum for enzymic hydrolysis has not yet been found.

Whether we shall call substances organizers or evokators[8] is of no importance. The only important thing is that purely materialistic causes, some relatively simple products of protein disintegration of the tissues, are able to cause malformations. To judge from our experiments, we closely approached the possibility to isolate, by means of an analysis of the products of tissue disintegration, those chemical substances that in lower vertebrates induce the development of tissues and organs. It may be expected that by applying these methods to higher vertebrates and to mammals, in particular, we will be able to find new powerful methods of stimulating the healing of large wounds, where the regeneration of great amounts of tissues is required, thus finding practical application for our theoretical work.

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PARASITOLOGY

DEVELOPMENTAL CYCLE OF *IXODES PERSULCATUS*, TRANSMITTER OF THE TICK ENCEPHALITIS IN THE MARITIME PROVINCE, FAR EAST OF THE USSR

By N. GRUZDEVA

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The data available in literature as to the three-year-cycle of the development of *Ixodes persulcatus* were largely obtained under conditions prevailing at the Leningrad province [Alfeev (1940) and others]. As a result of an analysis of the seasonal phenomena observed in the life of *Ixodes persulcatus* at the Far East Sea coast and at the Western Sayan (expedition organized by E. N. Pavlovsky for the study of the tick encephalitis) G. V. Serdiukova (1940) has also arrived atthe conclusion that the developmental cycle of this species was a three-year one.

The data available are not sufficient, however, to consider the duration of the biological cycle of the species in question as safely established, since they were obtained under different ecological and climatic conditions. Besides, some points that are of prime importance for the determination of the length of the developmental cycle have not been given sufficient attention. To these belongs the question as to the possibility of hibernation of ticks at various phases of their metamorphosis under natural conditions, and the period of their metamorphosis under typical conditions of the transmitter's habitat.

This made me start observations on the length of separate phases of the metamorphosis of the principal transmitter of tick encephalitis, *Ixodes persulcatus*, by breeding it at different phases of metamorphosis, both under natural and laboratory conditions.

The work was started in 1941, at the Suputinsky reserve which had been found by E. N. Pavlovsky, G. V. Serdiukova, A. Shubladze, V. Soloviev, B. Pomeranzev, N. Ryzhov, A. Skrynnik and others to be a natural focus of tick encephalitis. Along with our observations, the species was studied for its seasonal dynamics directly in nature, and for the dynamics of larvae and nymphae parasitic of wild animals, mainly of rodents. The larvae and nymphae became especially numerous by the end of May, in June and in August.

Starving females and nymphae collected from diverse animals of the tayga, and larvae hatched in cages, were fed on rabbits and kept in cages in the tayga and in the laboratory. In both cases temperature and humidity were measured daily. The data obtained as to the duration of separate phases of metamorphosis are summarized in the table below.

From an analysis of the periods of development and the temperature and humidity regime it is evident that longer periods correspond to seasons with a rather low temperature and, conversely, the periods of moult and egg development are appreciably curtailed by the and of July and in August, i. e. at the period

Period of feeding / Kept at	April		May				June				July				August			
	16—30		1—15		16—31		1—15		16—30		1—15		16—31		1—15		16—31	
	Laboratory	Tayga	Laboratory	Tayga	Laboratory	Tayga	Laboratory	Tayga	Laboratory	Tayga	Laboratory	Tayga	Laboratory	Tayga	Laboratory	Tayga	Laboratory	Tayga
Metamorphosis phase:																		
1. Feeding of females . . .			5 to 10 days															
2. From falling off of fed females to oviposition . .	17	—	12	—	10	11	7	4	4	7	7	10	—	—	—	—	7	13
3. Development of eggs . .	57	—	47	—	42	66	38	65	40	50—60	38	55	—	—	—	—	—	—
4. Feeding of larvae . . .			3 to 5 days															
5. Period of moult of larvae into nymphae, in days, after the fed larvae fall off	—	—	—	—	—	—	—	—	—	—	—	—	30	30	30	36	42	—
6. Feeding of nymphae . .			5 to 6 days															
7. Period of moult of nymphae into imagoes, in days, after the fed nymphae fall off	—	—	—	—	57	69	52	—	—	—	—	—	45* 37** 38***	30	40** 32** 35	27	—	—
Maxima and minima in°C .	10	—2	20	0	—	—	30	—	8	—	28	—	15	—	26	—	15	—

* After drowning during 11—12 days. ** After drowning during 2—3 days. *** After drowning during 3 days.

of maximum temperatures and high humidity. Owing to this, the hatching o larvae corresponded to the end of July and to August.

The results of our experiments are corroborated by observations carried out under natural conditions which have also shown the number of ticks on animals of the tayga to increase in August. Under laboratory conditions characterized by a higher temperature, as compared to that of the tayga, the developmental periods are somewhat shorter.

Conclusions

The terms of egg-laying after the female falls off the animal it is feeding upon, the duration of the development of the eggs and that of the moult of larvae into nymphae and nymphae into imagoes, depend upon the period of the season when the ticks go through a given phase of metamorphosis.

The numerical growth of the nymphae and larvae under natural conditions as observed towards the end of May and the beginning of June points to the hibernation of these stages, since the temperature regime prevailing during these seasons requires rather prolonged terms of development and makes it impossible that the development of a given stage be completed within one and the same season.

The second peak in the numerical growth of larvae as observed in August is due to the development of the eggs laid by females which have been feeding during the same season, in April, May and partly in June, thus corresponding to the warmest season rich in rainfalls.

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PARASITOLOGY

SUSCEPTIBILITY OF THE HEN TO CENTRAL ASIATIC TICK RELAPSING FEVER SPIROCHAETE *(SP. SOGDIANUM)*

By E. N. PAVLOVSKY, Member of the Academy, and A. F. CHESKIS

Some research workers have tested the susceptibility of birds to the tick relapsing fever spirochaete. Among these, Nicolle and Anderson found that the hen was refractory to infection with *Sp. hispanicum* var. *marrocanum*, and André Sergent (1936) found that the hen was positive in three cases of four to an Algerian strain of the Spanish-African relapsing fever spirochaete. These three cases were non-apparent, but subinoculation of their blood into guinea-pigs yielded positive results.

We wished to test the susceptibility of the hen to the Central Asiatic tick relapsing fever spirochaete, *Sp. sogdianum*. We used a strain isolated from ticks gathered in Kirghizia.

We infected three hens with heavily infected blood from guinea-pigs suffering from experimental tick relapsing fever. The blood of these hens taken from the comb was examined in thick drop smears stained by the Giemsa stain and was also subinoculated into guinea-pigs at definite intervals after the infection of the hens. The blood of these guinea-pigs was studied for spirochaetes over a period of 15 days.

H e n 1. Infected 19.X.1937 through the conjunctival route. Blood negative for spirochaetes. Guinea-pigs infected on the 6, 9 and 15th days after the infection of the hen, negative for spirochaetes.

H e n 2. Infected 19.X.1937 through the subcutaneous route. Blood negative for spirochaetes. Guinea-pigs infected on the 6, 9 and 15th days after the infection of the hen, negative for spirochaetes.

H e n 3. Infected 19.X.1937 through the subcutaneous route. Blood negative for spirochaetes. Guinea-pigs infected on the 6, 9 and 15th days after the infection of the hen, negative for spirochaetes.

From this we conclude that the hen is not susceptible to infection with the Central Asiatic tick relapsing fever spirochaete, *Sp. sogdianum*.

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PARASITOLOGY

SUSCEPTIBILITY OF THE DOMESTIC PIG TO CENTRAL ASIATIC TICK RELAPSING FEVER SPIROCHAETE

By E. N. PAVLOVSKY, Member of the Academy, and A. F. CHESKIS

In Spain and North Africa, the tick *Ornithodorus erraticus* (sometimes called *O. marrocanus*) has been found in pigsties in close association with pigs, the latter being one of its hosts. It was therefore suspected that the pig might serve as one of the natural reservoirs for the tick relapsing fever spirochaete strains belonging to the Spanish-African group isolated in Spain, Morocco, Tunis and Algiers. Sadi de Bouin, Ortego, Nicolle and Anderson, Delanoe, Velu, Balozet and Zottner, André Sergent and Brumpt described attempts to infect the domestic pig with this disease.

These authors, among whome some received positive results with the infection of the pig with tick relapsing fever, conclude that although infected *Ornithodorus* live in close association with domestic pigs, the sensitivity of the pig to *Sp. hispanicum* is too feeble for it to be considered that this animal plays anything more than a negligible rôle in the natural conservation of this virus.

In Central Asia, *Ornithodorus papillipes* is also often found in close association with pigs. In our experiment we wished to test the susceptibility of the domestic pig to two strains of the Central Asiatic group of the tick relapsing fever spirochaete (*Sp. sogdianum*). Strain A was isolated from *O. papillipes* found in a deserted pigsty in the Fergan City, Uzbekistan SSR. Strain B was lot «ZH» virus Kirghizia.

The first part of the experiment consisted in an attempt to infect two suckling pigs (several months old) through the nasal and conjunctival routes with blood from a guinea-pig infected with strain A. According to Remlinger and Bailly, this has been found to be one of the best methods of producing infection, due to its simplicity and the constancy of results which it gives with the guinea-pig and other susceptible animals. The blood of these pigs was studied daily over a period of 30 days in thick blood smears stained by the Giemsa stain. At intervals, beginning with the seventh day, blood taken from the ears of these pigs was subinoculated into guinea-pigs. The blood of the latter was also studied in thick blood smears for not less than 15 days after their infection. At the end of 30 days the pigs were sacrificed and their internal organs studied both in histological sections of the different organs, stained by the silver impregnation method of Levaditi, Dobell modification, and in wet prints of the organs stained by the Giemsa stain.

Pig 1. Infected 7. VI. 1936. No visible symptoms of the disease. No spirochaetes found in the blood. Blood proved avirulent for guinea-pigs. Histological sections of the various organs: spleen, liver, kidneys, heart, lungs and brain, negative for spirochaetes.

Pig 2. Infected 7. VI. 1936. Same as Pig 1. Emulsion of the brain injected intraperitoneally into guinea-pig proved negative for spirochaetes.

The second part of the experiment was performed on 4 young pigs, 4 weeks of age. Two cm^3 of highly infected blood from guinea-pigs infected with strain B were inoculated through the subcutaneous route in the abdominal region. There was one control. The rectal temperature of the five animals was measured daily over a period of 30 days. On the 10, 14, 15, 21 and 28th days after the infection of the pigs, their blood was subinoculated into guinea-pigs and the blood of these latter examined daily for spirochaetes over a period of 15 days. Two of the pigs died on the 22nd day of the experiment from an intestinal disorder, and emulsion from their brains was subcutaneously inoculated into guinea-pigs. Wet prints were made of all of the organs while warm and stained by the Giemsa stain.

Pig 3. Infected 27. X. 1936. Temperature measured over 30 days varied only within normal limits. No visible symptom of the disease; no spirochaetes found in the blood; the guinea-pigs subinoculated with the blood of this pig did not become infected.

Pig 4. Same as Pig 3. Died on the 22nd day from an intestinal disorder. Brain proved avirulent for guinea-pigs. Smears of the organs were negative for spirochaetes.

Pig 5. Same as Pig 3.

Pig 6. Same as Pig 3.

Conclusions. The breed of domestic pig found in the Moscow region of the USSR is not susceptible to infection with two of the strains of the tick relapsing fever spirochaete (*Sp.sogdianum*) isolated from *Ornithodorus papillipes* found in Central Asia (Uzbekistan and Kirghizia).

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